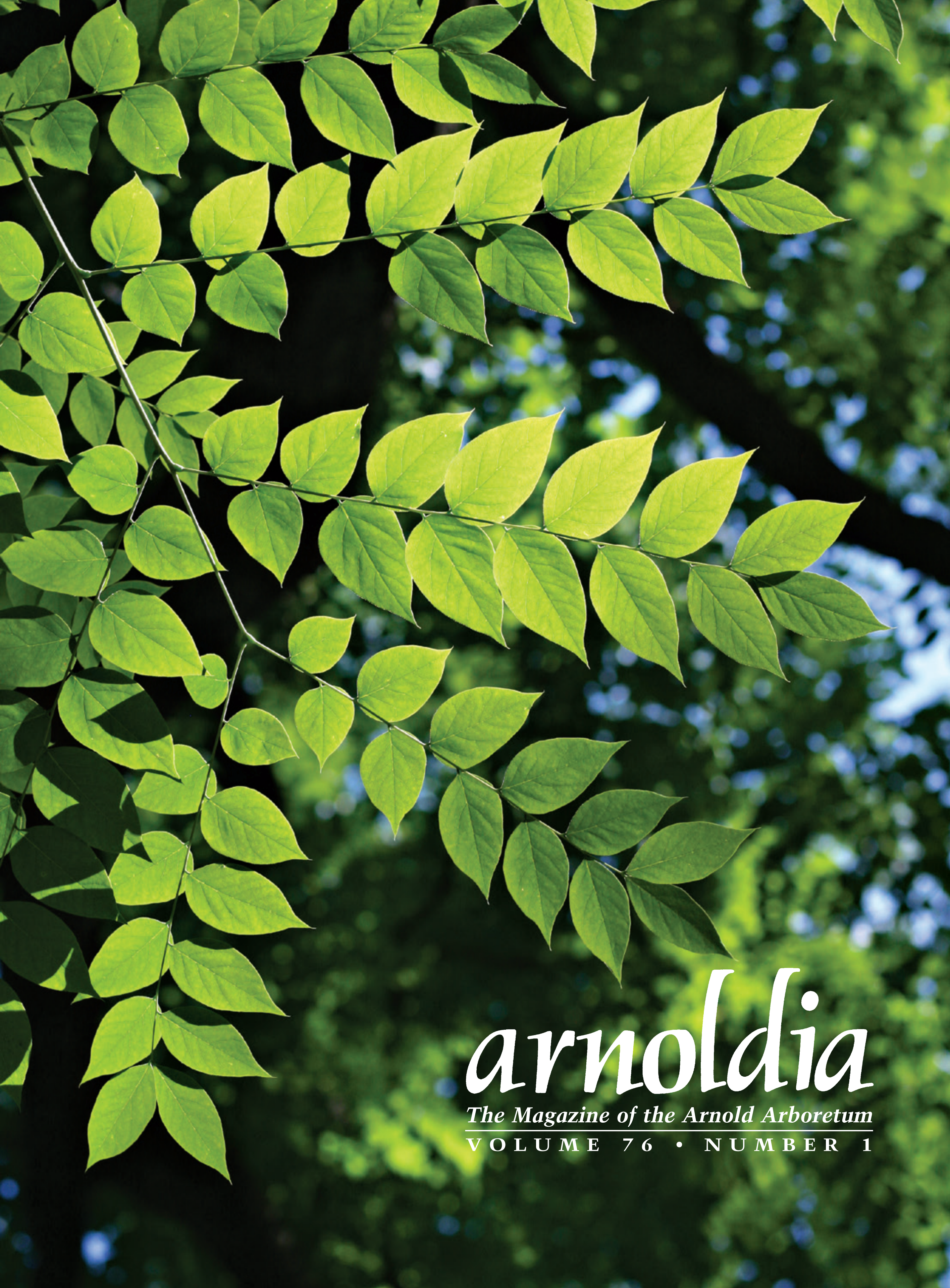
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The ARNOLD ARBORETUM of HARVARD UNIVERSITY

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Front cover: Leaves of the Kentucky coffeetree (*Gymnocladus dioicus*) can measure three feet (nearly one meter) in length. Each leaf is bipinnately compound, with small leaflets (pinnules) produced along secondary axes called a rachillae. Only part of a single leaf (accession 20644*A) is illuminated here. Photo by Jonathan Damery.

Inside front cover: Ernest Henry Wilson photographed *Gymnocladus chinensis* growing in Western Hubei, China, in 1910. The Arnold Arboretum has never successfully cultivated this endemic Chinese species, despite efforts dating to 1889. One other member of the genus, *Gymnocladus burmanicus,* is known from India. Photo from Arnold Arboretum Archives.

Inside back cover: This lone white oak (*Quercus alba* 346-2010*A) has grown on Peters Hill for at least two centuries. Photo by Michael Dosmann.

Back cover: "These nuts are much relished as sweetmeats," Frank Meyer wrote of the Chinese hickory (*Carya cathayensis*), which he photographed in Zhejiang Province (formerly Chekiang) on July 10, 1915. "They are said to yield as much as 25% of their weight in a clear yellow oil, which is used in fancy pastry and for other culinary purposes." Photo from Arnold Arboretum Archives.

Exploring the Native Range of Kentucky Coffeetree

Andy Schmitz and Jeffrey Carstens

Morning temperatures clung above freezing when we pulled our minivan onto the dirt roads of Elm Creek Ranch, southeast of Shamrock, Texas. It was March 2015, and we were searching for seed of Kentucky coffeetree (*Gymnocladus dioicus*). Although we never would have expected to find the species growing in the Texas Panhandle, beyond the range shown on distribution maps, a 2007 herbarium voucher confirmed it was "locally common" on the property. The ranch manager, J.C. Brooks, led us to the namesake waterway, which has cut a deep ravine through the dry grasslands. Most of the tree species followed this creek, and sure enough, tucked near stands of mesquite (*Prosopis glandulosa*) and western soapberry (*Sapindus saponaria* var. *drummondii*), several coffeetrees were growing.

The coffeetrees stood small and stunted—the largest barely exceeding thirty feet—and the pickings were slim, with only a handful of the thick leguminous pods dangling in each tree. We quickly went to work shaking the pods free and recording measurements and habitat data.

A native population of coffeetrees (*Gymnocladus dioicus*) at Elm Creek Ranch, Collingsworth County, Texas, was found beyond the conventionally recognized range for the species. William Carr, J. C. Brooks, and Bob Fulginiti collected the herbarium specimen (TEX 00433298) that first pinpointed this location in 2007.

Kentucky coffeetree (*Gymnocladus dioicus*) stands among the largest North American members of the bean family (Fabaceae). Andy Schmitz has collected an original copy of this hand-colored engraving by Pierre-Joseph Redouté, along with other *Gymnocladus* prints. The engraving first appeared in Henri-Louis Duhamel du Monceau's sixth volume of *Traité des Arbres et Arbustes que L'on Cultive en France,* published in 1815.

Three hours later, the temperature had rocketed to 74°F (23°C), and we drove away almost giddy about collecting Kentucky coffeetree in Texas.

By this collection on the fifth day of a nine-day expedition, our van was filling with bags of the beautiful yet odoriferous pods—collected from sites in Oklahoma and Kansas, in addition to Texas. The dash had become covered with stout sticks, which would eventually become herbarium vouchers. At a gas station one afternoon, a man noticed our unusual dash collection and interjected with understandable and friendly curiosity, "Mind if I ask, what's with the branches in your window?"

Coffeetree Collaboration

Our 2015 collecting expedition marked the sixth year of a partnership between the Brenton Arboretum, located in Dallas Center, Iowa, and the National Plant Germplasm System (NPGS) genebank in Ames, Iowa. The partnership has aimed to develop a comprehensive collection of Kentucky coffeetree—sampling populations from across the range of the species, which extends from Ontario through central Arkansas, from west-central Ohio through Oklahoma, along with parts of Kentucky and Tennessee. Although the trees in Texas were scraggly and small, many of the specimens we have seen throughout the years have been impressively grand, measuring well over one hundred feet tall.

We think *Gymnocladus dioicus* should be planted more widely in urban environments. The species has no serious insect or disease problems; it is drought tolerant and adaptable to tough soil conditions; moreover, it is exceedingly attractive, with distinctive bark (even at a young age), interesting compound leaves, and yellow fall color. The species should be included among the diverse tree genera that are used to replace ashes (*Fraxinus*), removed because of emerald ash borer (*Agrilus planipennis*), and oaks (*Quercus*), suffering from oak wilt (*Bretiziella fagacearum*). Yet if *Gymnocladus* is planted more broadly, we realize that a collection of diverse germplasm will be needed—both now and far in the

MICHAEL DOSMANN

Andy Schmitz stands beneath an exceptional coffeetree in Aurora, New York, which proved to be the largest specimen observed by Carstens and Schmitz over ten years of collections. This cultivated tree measured 110 feet (33.5 meters) tall, 60 feet (18.3 meters) wide, and 57.3 inches (1.4 meters) in trunk diameter at breast height, earning a big tree score of 305 and recognition as a New York state champion.

future—to make selections adapted to regional climatic conditions and to preserve germplasm for potential reintroduction into the wild.

The Brenton Arboretum's first collecting trip occurred in 2008, but plans for the project originated in 2004, as the institution contemplated developing a Nationally Accredited Plant Collection through the American Public Gardens Association's Plant Collections Network (PCN) program. Botanical research had been part of the Brenton's mission since it was established in 1997. After meeting with Mark Widrlechner, horticulturist at NPGS and the PCN's Iowa recruiter, Kentucky coffeetree was determined to be an excellent focus. *Gymnocladus dioicus* was not currently a PCN collection, and the NPGS had only six viable seed accessions of the species from known wild origins. Moreover, everyone agreed *Gymnocladus* was definitely underused in urban landscapes.

Prior to 2004, the Brenton had eleven accessions of Kentucky coffeetree, but none were wild collected. Andy Schmitz, the director of horticulture, made the Brenton's first wild collection of *Gymnocladus* in 2008 at Ledges State Park in Boone County, Iowa. He made a few additional collections the following year, but he knew that as the only horticulturist at an arboretum operating under a small budget, additional help was needed to make their future PCN collection a reality. This solidified a long-term relationship between two Iowa horticulturists: Andy Schmitz and Jeffrey Carstens at NPGS.

Collecting Seed and Data

One of the many benefits of having two institutions striving towards a common goal of preserving genetic plant diversity is the shared work load, especially during the preparation for a collection trip. The success of each trip is largely dependent on the initial identification of specific collecting locations. For the 2015 expedition, for instance, herbarium records and floristic surveys were referenced to identify the anomalous population in Texas, as well as other populations near roadsides and deep canyons, creeks and national battlefields. Further communication with property owners and local botanists—including those who collected the original herbarium specimens—is also beneficial, whenever possible.

Local contacts occasionally provide us with GPS coordinates for fruiting specimens, but our efforts typically depend on a pair of high-quality binoculars. The characteristic brown pods are easily recognized from considerable distances (even when observed at sixty-five miles an hour) and resemble a flock of blackbirds perched high in the canopy. Thankfully, the fruits are persistent from October through May, allowing us to collect in the winter, when they are highly visible in the leafless canopy. (What other species provides a more than six-month window of fruit senescence?) Collections in early to mid-winter were difficult, however, because the stringy and tough peduncle does not release the fruits as easily, whereas roughly six weeks before bud break, the fruit is easily shaken from the tree.

After we have spotted the trees, teamwork makes the seed and data collection easier. Our collection on March 4, 2013, illustrates our basic procedure. On the third day of a nine-day expedition through southern Indiana and Kentucky, we were truly looking forward to exploring Griffith Woods, south of Cynthiana, Kentucky, which is known for harboring the world's largest chinkapin oak (*Quercus muehlenbergii*) within an exceptional old-growth savannah. As soon as we pulled into the parking lot, we could see fruiting coffeetrees on the distant horizon. Although we harvested from seven trees, the find of the entire trip was the sixth—discovered some four hours later. This was the second-largest coffeetree we had ever seen, measuring 120 feet (36.6 meters) tall, 46.5 feet (14.2 meters) wide, and 42.0 inches (1.1 meters) in trunk diameter at breast height, and it currently reigns as the Kentucky state champion. To harvest seeds from such a large tree, we used a Big Shot® line launcher to accurately propel a weighted bag and line over branches high in the canopy. We then used the line to shake pods free. The launcher—a slingshot mounted on an eight-foot pole—has proved its worthiness over and over. On early trips, before using the launcher, we averaged up to two hundred seeds per tree, but now we average six hundred to eight hundred.

BOB CUNNINGHAM

Jeffrey Carstens uses a pole-mounted slingshot to collect pods along the North Folk River in Douglas County, Missouri. At right, coffeetree pods at the Brenton Arboretum.

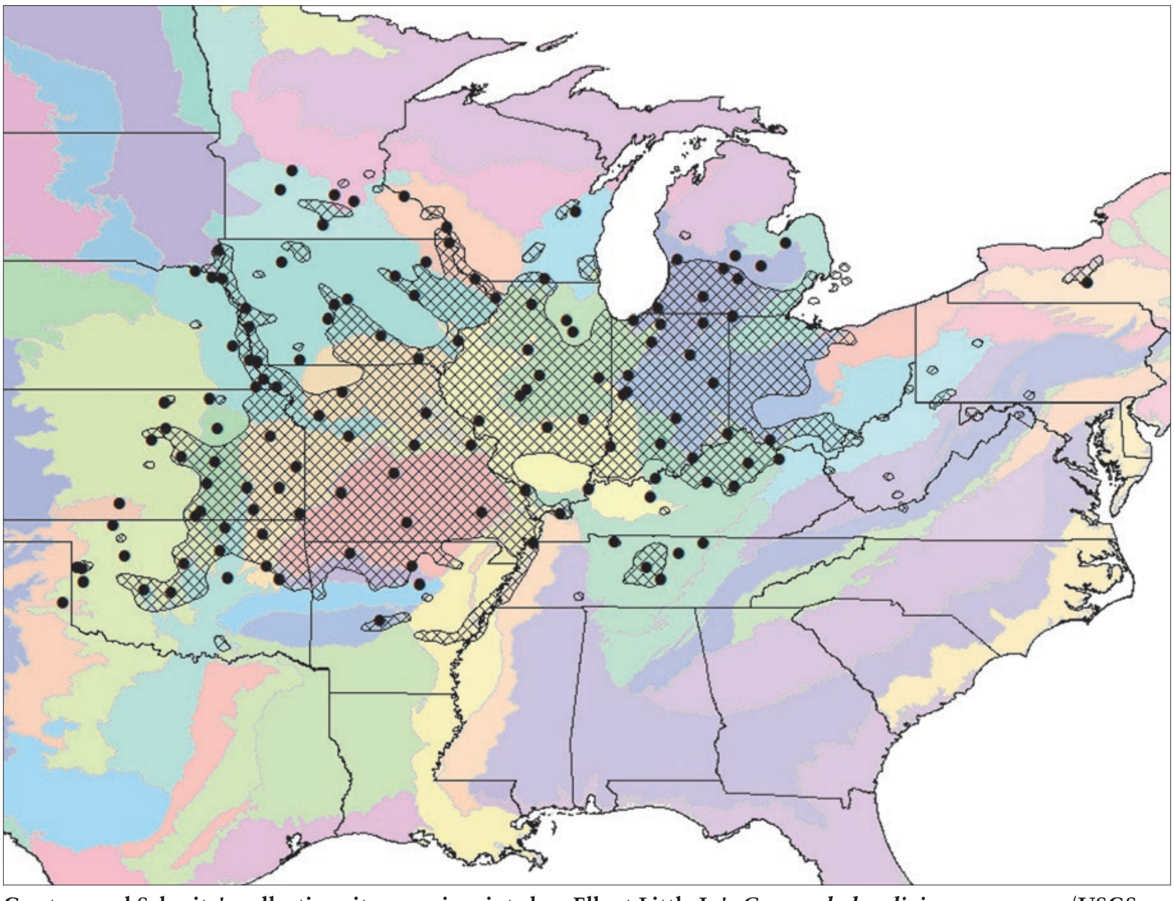
The collection time at each mother tree takes around forty-five minutes. Jeff is the "shaker" while Andy is the "gatherer." Ideally, enough pods are shaken to the ground to fill one or two five-gallon buckets. While the pods are gathered and packed into labeled sacks, we record GPS coordinates, elevation, associate species, habitat notes, and descriptions of plant health and abundance. Over the years, we expanded our data collection to include height and trunk girth (diameter at breast height) for each mother tree, along with trunk measurements for all woody species over four inches (ten centimeters) within a prescribed area (calculated with a small lens, known as a ten-factor wedge prism). We take herbarium vouchers of branches and fruits, which are later deposited at regional herbaria, and we also photograph each tree in the field. (Back at NPGS, we also scan images of the fruits and seeds for each tree, so that precise dimensions are documented.) Our goal is to capture the potential genetic diversity at every site. Sometimes we collect seed from six to eight mother trees, but this has ranged from two to ten. Sometimes the trees are found less than a few hundred yards apart in a forested area, and other times as much as five miles apart along a river corridor.

After we collected from the massive specimen at Griffith Woods, the afternoon sun was setting fast. We never found the record chinkapin oak, because everywhere we turned, massive lookalikes made us freeze in our tracks in admiration. We collected from one other coffeetree—our seventh for the site—and then, as we walked back to the van at twilight, we were startled by a black object moving in the tall grass ahead of us. When our eyes focused, we came to realize it was a skunk. Good thing for us (and for the hotel staff), the skunk disappeared without incident. Soon afterwards, several wild turkeys flew overhead, landing in the brush to roost for the night.

Observations on Abundance

To cover the entire native range of Kentucky coffeetree, we have targeted collection sites approximately seventy-five miles apart within distinct watersheds. We have also aimed to collect from every possible Omernik ecoregion (Omernik, 1987), in an effort to find the best representation of genetic diversity across as many unique habitats as possible. To date, we have made at least one collection from twenty of twenty-two ecoregions within the core range, although small disjunct populations could occur in another twelve. Our first extended collection trip occurred in 2010, when we spent eight days on the road making thirteen collections in six states (Iowa, Missouri, Arkansas, Illinois, Indiana, and Tennessee). On future trips, we usually focused on a single state or a few adjacent states, often targeting two collection sites per day, sometimes as much as one hundred miles apart. On all trips, our work started before sunrise and ended after sunset.

Looking at the range map for *Gymnocladus dioicus* in Elbert Little Jr.'s *Atlas of United States Trees*, we might assume the species would be well represented near the central part of the range and become scarcer towards the edges, but this assumption does not hold true. Missouri, for instance, is centered within the native range, and approximately 80 percent of the state's



Carstens and Schmitz's collection sites are pinpointed on Elbert Little Jr.'s *Gymnocladus dioicus* range map (USGS, 1999), which has been superimposed over color-coded Level III Omernik Ecoregions (Omernik, 1987).

counties document its presence (Kartesz, 2015). Yet out of nine Missouri populations that we've sampled, finding more than twenty-five trees proved difficult, especially in the southeastern corner of the state—nearly the center of the range. Jeremy Jackson, from the United States Army Corps of Engineers, supplied us with forestry plot data for the Wappapello Lake Project in Wayne County, which demonstrated that only three genetically distinct colonies occurred within the ten-thousand-acre property. Our first-hand observations confirmed this scarcity. This aligns with observations by Gifford Pinchot, the first chief of the United States Forest Service, whose 1907 report suggested that coffeetree was one of the rarest forest trees despite its rather extensive range and that, in large areas within the range, the species was "entirely lacking or represented only by an occasional individual."

For this reason, we were especially intrigued by an 1899 report from the geologist Robert Ellsworth Call, which stated coffeetree was "of very common occurrence" along aspects of Crowley's Ridge, a geological formation that runs from southeastern Missouri through northeastern Arkansas, paralleling the alluvial plain of the Mississippi River. We wanted to target Crowley's Ridge during our first joint collecting trip, so we spent numerous hours searching the internet and communicating with botanists hoping to pinpoint locations. Only one botanist—a man who had spent more than thirty years studying the area—could tell us of a single population along the ridge. What changed over the past century that has caused the "very common" to become rare? Certainly this period coincided with environmental transformations rendered by agriculture, deforestation, grazing, and timber use. Based on our observations, Ken-

Coffeetrees proved most abundant on the western edge of its range, where the environment is the most hot and dry. Carstens and Schmitz encountered this specimen growing along a gravel road in Roger Mills County, Oklahoma.

tucky coffeetree is essentially rare throughout the eastern three-quarters of its native range.

While Little's map does not capture this off-centered distribution, general patterns hold true. In 2010, we spent almost a full day scouring areas south and west of Carbondale, Illinois, covering hundreds of miles in and near the LaRue-Pine Hills Research Natural Area, where limestone and sandstone outcroppings tower over the Mississippi River bottoms, yet we only found one lone tree at the base of Fountain Bluff. Our struggle to locate the species in this region aligns perfectly with Little's map, which shows a distribution gap for southern Illinois. In Michigan, on the northern edge of the native range, numerous botanists have kept an eye out for coffeetree due to its rarity. During a seven-day tour of the state in 2016, we were able to locate coffeetree only at locations that had been provided to us and at no additional sites, thus confirming its rarity. In Minnesota, the map shows a few disjunct populations. Our sampling, again dependent on the observations of other botanists, found *Gymnocladus dioicus* to be infrequent but locally common along watersheds of the Minnesota and Blue Earth Rivers, which once again aligns with Little's map.

Compared to other states sampled, *Gymnocladus dioicus* is quite abundant in Oklahoma and Kansas, where it could be considered a dominant forest species at some sites. Perhaps a combination of historical and current land management practices allow it to sustain and regenerate within these two states.

Observations on Habitat

When we initially started making seed collections of *Gymnocladus* near Iowa, we specifically targeted watersheds and bottomlands, as

By day nine of the collecting trip through Kansas, Oklahoma, and Texas, Schmitz and Carstens had packed their van with 1,335 pounds of pods and seeds.

Andy Schmitz stands beside a multi-stemmed coffeetree on dry bluffs overlooking the Arkansas River in Osage County, Oklahoma. Trees were also found on the nearby floodplain, demonstrating the remarkable adaptability of the species.

this is where we found the species naturally occurring; moreover, this preference for moist locations concurred with descriptions in scientific literature. Yet, over the ensuing years, our understanding of the species began to change. When we collected in central Michigan in 2016, we noted that even though the majority of the specimens were growing in extremely wet bottomlands, adjacent to major rivers, many displayed signs of root rot and decline. Whether these Kentucky coffeetrees really preferred to be in such wet conditions was questionable.

In southern Indiana and Kentucky, for instance, *Gymnocladus dioicus* occurs on upland bluffs and steep slopes with loose soils and occasionally on bedrock. The Loess Hills of western Iowa, which follow the Missouri River, support substantial specimens of *G. dioicus* on all aspects of their slopes. In Iowa and Illinois, human settlement and introduction of the plow has likely eliminated many *G. dioicus* in open fields and has left remnants only in areas too wet or steep for modern agriculture. Coffeetree was found in a variety of habitats in Missouri, including moist ravines, dry rocky slopes, and major and minor watersheds. On the western edge of its native range in Kansas and Oklahoma, coffeetree occupies dry ravines and hillsides, open pastures and bedrock. All six sites sampled in Tennessee were collected off cool north- to northeast-facing slopes, showing a definite variance compared to other states.

While most sites tend to have rather uniform habitats for all trees sampled, a few possessed specimens growing in remarkably different conditions. Along the Minnesota River in south-central Minnesota, coffeetrees grow on bottomland alluvial soils as well as on three-billion-year-old granite outcrops, emphasizing the ability of the species to perform on an extreme spectrum of harsh growing conditions. Specimens at the Tallgrass Prairie Preserve in northeastern Oklahoma demonstrate similar adaptability: we found trees growing on shallow sandstone outcrops with blackjack oak (*Quercus marilandica*) and post oak (*Q. stellata*), and in moist floodplains with sycamore (*Platanus occidentalis*) and black walnut (*Juglans nigra*).

Ten years ago, we assumed silver maple (*Acer saccharinum*) would be a common associate, given our original understanding that *Gymnocladus dioicus* was a floodplain species, but in the end, silver maple has been documented at only 12 percent of our sites. Today, our efforts to find coffeetree typically require a watchful eye for common hackberry (*Celtis occidentalis*), often growing where wet habitat grades into slightly higher elevations or sandier soils. We have observed hackberry—the most common associate—at 62 percent of our collection sites, including on the edge of the Cass River in Tuscola County, Michigan, where we discovered *Gymnocladus* about seventy miles north of the presumed northern limit for its range. Hackberry and coffeetree regularly share upland locations as well.

The common belief that coffeetree is adapted for wet sites in the landscape likely stems from the occurrence of coffeetree amongst bottomland forests of major watersheds in the states of Iowa, Illinois, Minnesota, and Indiana, where sand and loam soils provide adequate drainage. Seeing a strong presence of *Gymnocladus* in Kansas and Oklahoma, more than any other states, suggests the species is well adapted for dry, hot environments.

Threat of Impermeable Seeds

On March 5, 2013, the day after our collection at Griffith Woods, Kentucky, we began before sunrise, heading northeast for the Fleming Wildlife Management Area. This site occupies the eastern edge of the range for *Gymnocladus* in Kentucky. Scott Freidhof, a wildlife biologist for the area, had provided us with GPS coordinates for coffeetrees there, and this information proved essential. The trees were a three-quarter-mile hike up to the top of a bluff, and because the forest cover was dense, there was no using binocs to spy pods from afar. With the GPS unit in hand, we attempted to take the most direct route to this localized population and scrambled straight up a steep slope. At the top, pods littered the ground, and we swiftly scooped up twenty-five gallons. The slingshot pole came in handy, not for slinging the throw line but for stringing up the bags of pods like wild game from a hunt. With one end of the pole on each of our shoulders, we made our way down the steep slope, only stumbling a few times on loose rocks or wet oak leaves underfoot.

SCOTT FREIDHOF

Because few living animals are known to disperse coffeetree seeds, an abundance of pods can sometimes be found beneath the trees, including here, in Fleming County, Kentucky. Andy Schmitz (left) and Jeffrey Carstens (right) carry a load of pods.

Why were so many seeds undisturbed on the ground? The Kentucky coffeetree has been referred to as a "botanical anachronism," one that was once dispersed by large prehistoric mammals that are now extinct (Zaya and Howe, 2009). Grinding molars and intestinal juices of the American mastodon (*Mammut americanum*) may have aided in scarifying coffeetree seeds, and perhaps just as important, these animals would have served as a major dispersal mechanism (Barlow, 2008).

Al Fordham, a prominent propagator at the Arnold Arboretum, conducted a germination experiment on *Gymnocladus* in 1965. He placed three hundred seeds in water, and within the first ten days, thirteen seeds germinated. Fordham suggested "these, no doubt had fissures in their seed coats." Over the next two years, only three more seeds germinated that were submerged in water. Coffeetree seeds are surrounded by a gelatinous material, which may serve as a protective barrier during the early to mid-maturation phases and perhaps later as a reward to animals willing to disperse them throughout the landscape, though which four-legged critters (if any) now move these fruits remains unclear.

Water may be a viable dispersal mechanism. We have observed pods falling into a river, and though able to float for a while, they eventually sink to the bottom, where abrasion provided by gravel and sand in the riverbed may provide the necessary scarification needed for germination. Yet how would such a heavy seed make its way back to shore to even have a chance at sprouting? At many collection sites, two- and three-year-old seeds can be found on the ground under the canopy of the mother tree, next to rotting pods from prior years. This is what writer Connie Barlow—drawing on the work of ecologists Dan Janzen and Paul Martin—described as the "riddle of the rotting fruit," caused when seed lies in wait for an extinct animal that will never come to carry it away. Our observations recorded little to no regeneration at almost all of our collection sites, illustrating a potential threat for the species within its native habitats.

KYLE PORT

An open coffeetree pod at the Arnold Arboretum, showing sticky pulp surrounding the seeds (accession 1181-83*A).

Habitat Loss and Ecological Changes

In 2015, the day before we collected *Gymnocladus* in Texas, we visited a site along the Washita River in Custer County, Oklahoma, where an existing NPGS accession (PI 649669) had been collected in 1993. Steve Bieberich, the owner of Sunshine Nursery in Clinton, Oklahoma, had collected the original accession. We met at his nursery, and he guided us to the site. Even with his help, we were unable to relocate any coffeetrees. By looking at historical photos, we realized a new highway bridge had eliminated *Gymnocladus* at this location back in 2005. This observation really hit home the importance of our collaborative effort to deposit seeds for long-term preservation. Fortunately, germplasm from this location is currently secure in the NPGS collection, and preserved seed could be used for reintroduction back into the Washita River watershed.

In addition to habitat losses like this, habitat modification poses another serious threat. Our main concern lies with *Gymnocladus dioicus* growing in floodplains of major watersheds. Thirty percent of our collections came from sites like this, but given that 82 percent of these plants were restricted to extremely well-drained soils, a slight change in hydrology (including increased frequency or duration of floods) would significantly impact tree health. At the Michigan sites where we observed serious signs of dieback and root rot,


Andy Schmitz poses with a grove of coffeetrees in Louisa County, Iowa. Between 2010 (left) and 2016 (right) the trees became overwhelmed with hops (*Humulus* sp.), causing significant coffeetree mortality that was compounded by increased flooding at the site.

we also noted a number of uprooted specimens with debarked trunks lying in water, their root bases sticking eight feet in the air. These collapsed specimens likely resulted from hydrological changes, given that we found fruiting trees on slightly higher ground a few yards away. For a species that comprises only a small percentage of forest canopies, any loss is critical to future conservation.

The threat of non-native invasive species (and even aggressive natives) is also significant. Nowhere was this more evident than on the Little Red River near Heber Springs, Arkansas, where back in 2010 it was virtually impossible to not get entangled in Japanese honeysuckle (*Lonicera japonica*) or bloodied by multiflora rose (*Rosa multiflora*). We also noted mature coffeetrees acting like trellises for grape (*Vitis* sp.) and poison ivy (*Toxicodendron radicans*) resulting in limb decline. That same year, we sampled a site along the Iowa River in Louisa County, Iowa, where we noted more than one hundred genetically distinct trees—the most coffeetrees we had ever seen in a single area. We could have literally collected truckloads of pods. However, when we returned to this location in 2016, we discovered that at least three-quarters of the coffeetrees were dead or in decline after becoming overgrown by hops (*Humulus* sp.). The area had also flooded numerous times, suggesting a simultaneous and significant change in hydrology. In these real-world situations, even if seeds could germinate or if clonal suckers sprouted, it seems unlikely a new generation of trees would ever have a chance to reach maturity.

Still Collecting

Despite threats to native populations of *Gymnocladus,* we have consistently observed the extreme toughness and adaptability of the species. Not only can it tolerate a wide variety of soils, but the trees are remarkably durable, withstanding severe ice and other unfavorable weather conditions. When we visited Obion County, Tennessee, in February 2010, we crossed the mighty Mississippi on the Dorena-Hickman Ferry and witnessed the aftermath of a major storm that had deposited over an inch of ice a year before our visit. The forest was entangled with downed trees and limbs. Most trees were uniformly broken off at a certain height, but fifteen coffeetrees stood undamaged, towering above the surrounding mess and calling like beacons to two boys from Iowa.

Over the past ten years, our travels have taken us across sixteen states in search of this one species: *Gymnocladus dioicus.* We have spent eight hours on a frigid boat ride on Michigan's Shiawassee River to document the species for a new county record. We have tested the shocks on our minivan after collecting 1,335 pounds of pods during our trip to Texas and back. We have avoided snow storms in northern Arkansas, but in Kentucky, we collected in the pouring rain. We have worn hip waders too many times to count and used scrapers to clear ice off the inside of the windshield (given the condensation that rises from wet pods stored inside the van). We met an oilman in Oklahoma who just so happened to have a coffeetree pod under the seat of his truck because he wanted someone to identify it for him. We're sure he never thought two guys from Iowa would make the positive determination, let alone two guys from Iowa who just so happened to be on the same backroad shaking the exact same pods from a tree. Our names are now linked to state champion coffeetrees in Kentucky, New York, and Oklahoma.

All told, we've travelled over twenty-five thousand miles and spent seventy-five days on the road, collecting over a quarter million seeds from more than five hundred mother trees. This has resulted in one of the most comprehensive tree seed collections ever preserved, including 88 seed accessions in the NPGS (GRIN, Online Database, National Genetic Resources Laboratory 2018) and 130 accessions of different wild provenances planted in three informal groupings at the Brenton Arboretum. Researchers in Ontario, Canada, are already using this expansive collection for genetic comparisons to their threatened native populations. In 2017, a replicated block of 750 trees was planted at the Plant Introduction Station in Ames, representing fifty wild populations (three mother trees per population and five trees per mother tree), which in time will help us to learn about pollinators, growth rates, and hardiness. Yet our fieldwork continues. We still aim to fill gaps within ecoregions and sample outlying populations and unique habitats. The state of Ohio is on our hit list because, to date, only one collection has been made there.

Jeffrey Carstens shows the collection of Kentucky coffeetree seeds at the National Plant Germplasm System (NPGS) genebank in Ames, Iowa. Seeds for each individual mother tree are kept in separate packages and are maintained at -18°C (0°F).

CRAIG SHIVES

Andy Schmitz stands at the entrance to the Brenton Arboretum's *Gymnocladus* collection, which achieved Plant Collections Network accreditation in 2016. Each of the trees (currently 130 wild-collected accessions) has enough space to reach its mature size, while creating an intertwined canopy.

More than anything, our adventures have allowed us the opportunity to experience the beauty of this species in the wild and to discover more than what we could ever find in any textbook or publication. In the words of the natural historian William B. Werthner, "If in your walks through the woods, you chance to come upon a Kentucky coffeetree, count yourself fortunate for it is the rarest of our forest trees." And if you do, please give us a call because we would sure like to know its location.

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Andy Schmitz has been the director of horticulture/general manager of the Brenton Arboretum for twenty years and oversees all horticultural aspects of the 143-acre arboretum, including planting, curating, and maintaining all plant records for over 2,500 woody accessioned plants. He enjoys observing trees in their native habitats while collecting seed to grow trees and shrubs to enhance the arboretum's collections, and his particular focus is on collecting the native Iowa woody plants for their Iowa collection.

Jeffrey Carstens is a horticulturist at the North Central Regional Plant Introduction Station in Ames, Iowa, where he currently serves as the curator for the collection of woody and herbaceous plants. He coordinates the NC-7 Woody Ornamental Evaluation Trials and is actively involved with collecting ash (*Fraxinus*) as part of the National Plant Germplasm System Ash Conservation Project.

Great Wild Gardens: The Story of the Arboretum's Woodlands

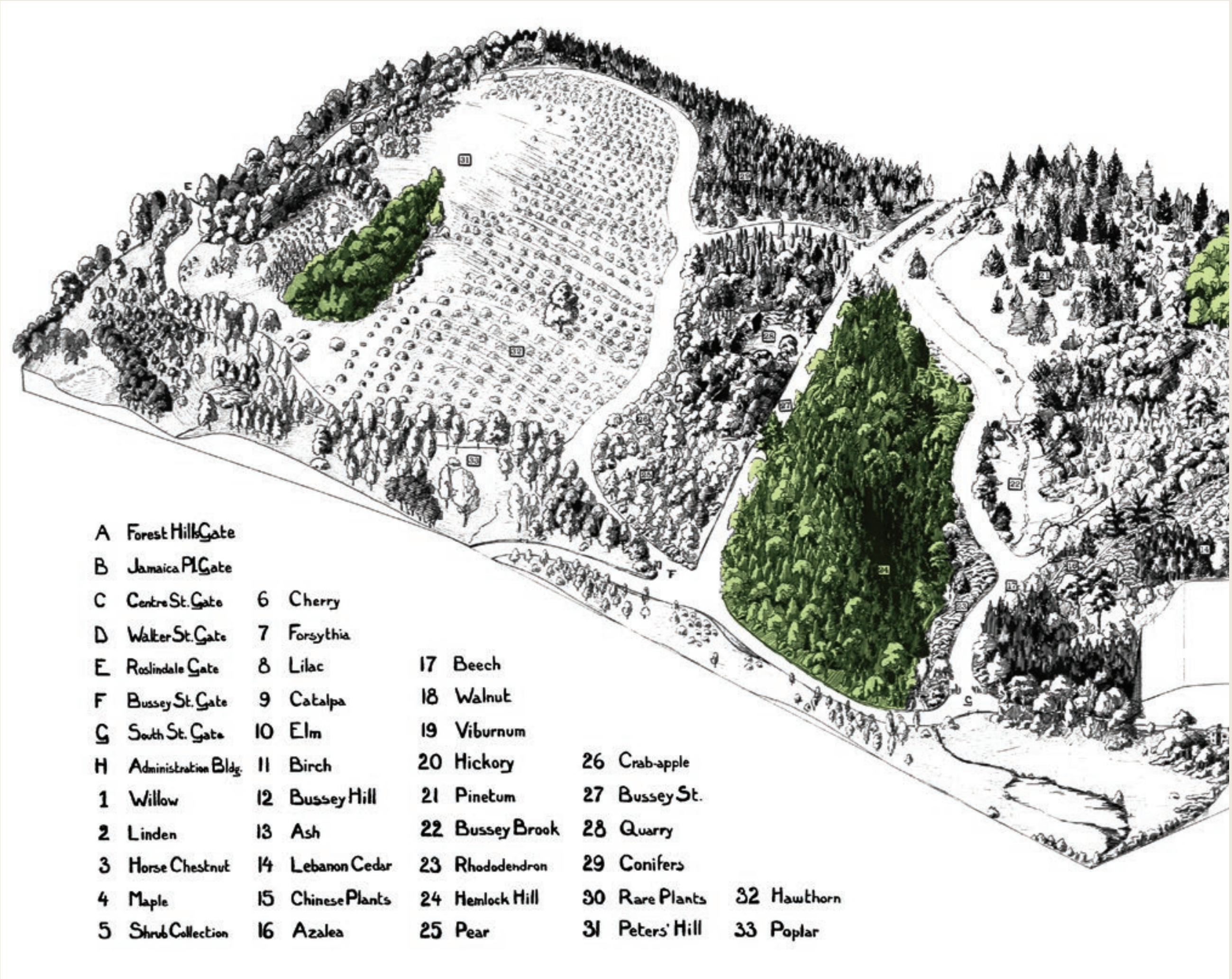
Danny Schissler

At the heart of the story of the Arboretum's woodlands lies a tension between the managed and the unmanaged, the natural and the constructed. From the beginning, the Arboretum's woodlands were intentionally excluded from formal development to serve as an aesthetic contrast to the taxonomically grouped collections. The Arboretum's first director, Charles Sprague Sargent, took careful inventory of the remnant woodlands included in the Arboretum's indenture. Rather than clear these areas for collections, Sargent, in concert with the landscape architect Frederick Law Olmsted, preserved these masses of native trees, noting their natural beauty and educational potential. "In no other public garden are there such cliffs or a more beautiful remnant of a coniferous forest," Sargent wrote of Hemlock Hill, one of the four main Arboretum woodlands. Of the other areas, he noted that large oaks and other deciduous trees—some more than two-hundred years old, according to his estimate—were valuable for illustrating "New England trees in their adult state."

Since Sargent's time, these four areas—North Woods, Central Woods, Hemlock Hill, and

DANNY SCHISSLER

Stands of sweet birch (*Betula lenta*)—seen here in brilliant fall color—take advantage of canopy gaps on Hemlock Hill.

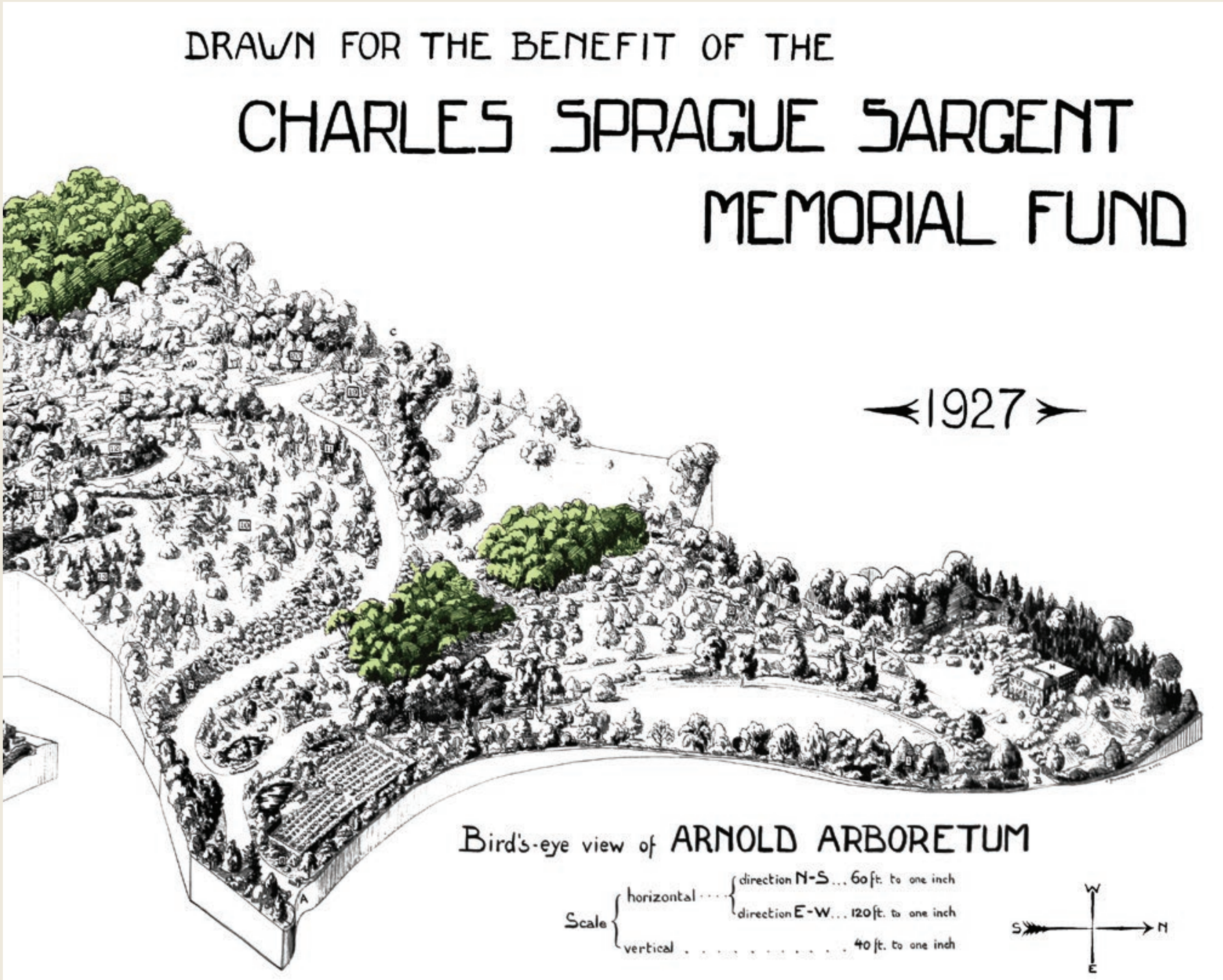


Four woodlands are traditionally recognized at the Arboretum, shown here from left to right: Peters Hill Woodland, Hemlock Hill, Central Woods, and North Woods. This map was hand-drawn by Jan Tijs Peiter Bijhouwer.

Peters Hill Woodland—have come to exemplify the concept of the "urban woodland," providing benefits along with management challenges unique to urban forest fragments. Today, these woodlands provide a naturalistic backdrop to the cultivated collections, offering a sense of spontaneity—whether in a fleeting glimpse of wildlife, discovery of a rare wildflower, or an unexpected encounter with a venerable old tree. Despite the seeming wildness of these areas, the woodlands and the ecosystems they support hardly represent the sort of pristine New England forest we might imagine them to be. On the contrary, they exist at the intersection of the intended and unintended consequences of human decisions—a sustained biological triumph over repeated broad-scale disturbances, creating a colorful mosaic of the native, the non-native, and the outright invasive, while raising questions about the very definition of so-called *natural* woodlands.

Woodland Hill

The woodlands inherited by Sargent at the time of the Arboretum's founding in 1872 bore the marks of widespread ecological disturbance, most of it regrown from worn cropland and pasturage. In a 1935 article on land-use history at



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the Arboretum, research assistant Hugh Raup (who would later be appointed the first plant ecologist on the Arboretum staff) examined deeds of conveyance, records of will, and other historical documents to catalogue the extensive parceling and transfer of properties that would eventually form the Arboretum. From Raup's historical rendering, we know with some certainty that during colonial settlement in the 1700s, the forested portion of the Arboretum's lands befell the same dramatic ecological disturbance as most central New England forests. Rapid deforestation provided fuel and lumber; clear-cut land with fertile soil was cultivated; and upland areas with thin, rocky soils provided pasturage and orchard land.

During that period, much of the Arboretum acreage passed through generations of the Davis, Morey, and Weld families. Raup used dendrochronology (a method of tree-ring dating) to show that nearly all of this land—with the exception of the steep slopes of what would later become known as Hemlock Hill—had witnessed the wholesale removal of mature trees. Early on, a saw mill had even been constructed on Bussey Brook. Then, in 1806, a wealthy merchant named Benjamin Bussey began purchasing properties in the area. He consolidated the land into an exemplary pastoral estate known as Woodland Hill, on which he would spend his well-earned retirement. Bussey was fascinated by horticultural and agricultural science, and among his three hundred acres of hillsides, meadows, ravines, and brooks, the retired merchant reared merino sheep and cultivated the land through the introduction of novel crop species, trees, and shrubs.

Bussey developed his country estate in accordance with the naturalistic English landscaping tradition that had recently permeated American design sensibilities. He targeted areas for reforestation as part of his landscape plan and opened his woodlands, in truly altruistic fashion, to any who wished to escape the bustle and din of nearby Boston. Margaret Fuller and her circle of transcendentalist thinkers visited Bussey's Woods, now known as Hemlock Hill, and she wrote fondly of the soaring hemlocks and pines found along the brook. Despite the rhapsodic reflections inspired by these woodlands, Raup's study of extant trees in 1935 suggests that the oldest hemlocks were scarcely older than thirty when Bussey acquired the hill among his first parcels and, hence, would have been little more than twice that age when Fuller became a frequent visitor.

Bussey's stewardship marked a period of rejuvenation for woodlands on the property, yet the ecological succession was nonetheless dictated according to the management practices of this genteel landowner. One local historian, drawing on the memory of older residents in 1897, noted that during Bussey's tenure, woodland paths had been carefully tended all over Hemlock Hill and that an arbor had been erected near the summit, allowing visitors to reflect on the pastoral vista. This aesthetic approach to landscape maintenance was also outlined in Bussey's will, where he dictated that, as long as his family still occupied the land following

ARNOLD ARBORETUM ARCHIVES

Benjamin Bussey's mansion and farm buildings were situated on the eastern slope of Bussey Hill—a short stroll from wooded paths on Hemlock Hill (then known as Bussey's Woods). This inset comes from a large map prepared by Guy Lowell in 1904. At that time, Bussey's home was on property maintained by the Bussey Institution, not the Arboretum.

ARNOLD ARBORETUM ARCHIVES

Ernest Henry Wilson captured the tranquil beauty of Hemlock Hill in 1923. The unidentified woman could be Wilson's daughter, Muriel.

his death, no trees should be removed, except when necessary "for the beauty of the groves and the walks." Presumably Bussey would have applied a similar approach to other woodlands—or rather thickets of young trees—as he acquired them. The areas now known as Peters Hill Woodlands and the North Woods were primarily ten to fifteen years old when Bussey died in 1842, while the Central Woods—located on rocky soil that was largely unsuitable for agriculture—was between twenty-five and fifty years old.

When Sargent took the helm of the Arboretum, his impulse to preserve these woodlands likely spanned the aesthetic and the practical; his views on the multitude of ecological benefits provided by preserved forests—including reduced compaction, mulch creation, windbreaks, and improved soil moisture—are well-captured in his 1875 report, "A Few Suggestions on Tree Planting," prepared for the Massachusetts Board of Agriculture. Sargent initially imagined that the woodlands would serve as plantations for the study of forestry and related sciences. In a letter to Boston's Department of Parks in 1879, Sargent described a "scientific station" that would allow for the investigation of "the best methods of forest reproduction and management" as well as "a school of forestry and arboriculture in which special students may … acquire the knowledge and training necessary to fit them for the care and increase of our forests."

Eventually, Sargent abandoned this forestry plan, yet he retained the three woodland areas later known as Hemlock Hill, North Woods, and Central Woods, prescribing a basic management regime of occasional thinning—more or less maintaining Bussey's vision for these wooded spaces. Later, a fourth woodland was added with the 1895 annexation of the sixty-seven-acre tract that became Peters Hill. A naturalistic blending of native woodlands and cultivated collections—producing a so-called

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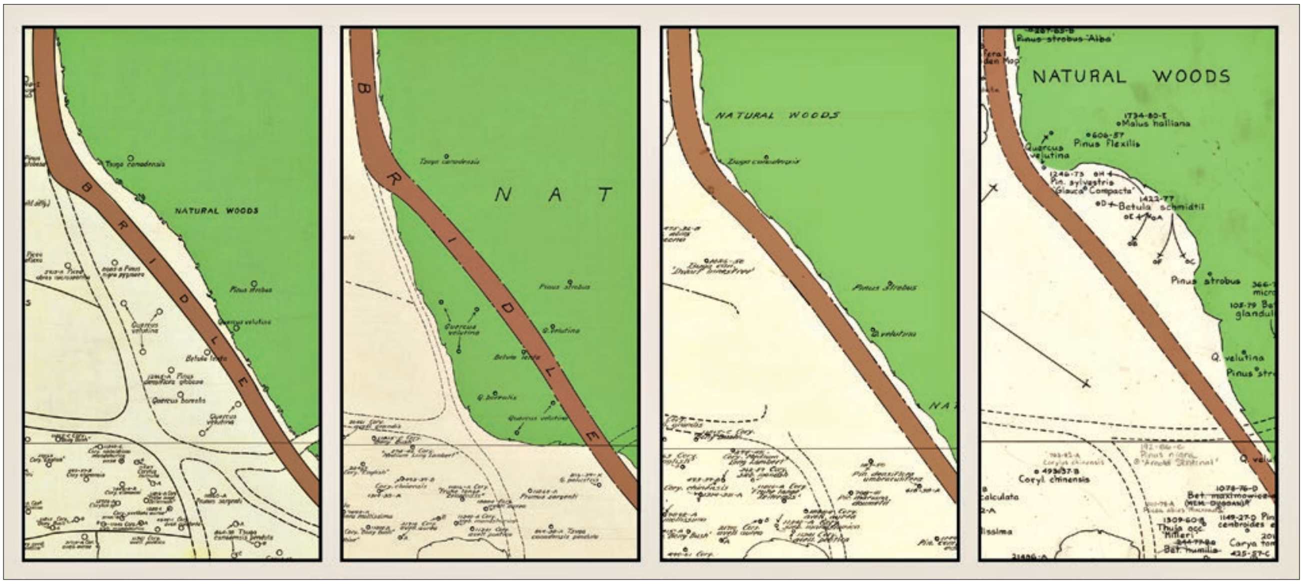

The undulating borders of Central Woods show the impact of landscape management over five decades. The woodlands were allowed to spread across Conifer Path (originally known as Bridle Path) before undergoing restriction to create space for new accessioned plantings. From left to right: 1937 (or 1938), 1952, 1964, and 1987.

landscape effect—formed the foundation for Olmsted's design and left a lasting impact on the institution's identity. Ultimately, the long legacy of human intervention that had shaped the Arboretum's woodlands would continue into the twentieth century and well beyond Sargent's time, as staff members grappled with a succession of natural and unnatural disturbances in these areas.

Managed Succession

Among the Arboretum woodlands, Hemlock Hill most clearly shows the ongoing process of human intervention. On a cold September evening in 1938, a four-day rainstorm crescendoed across New England. Violent wind gusts buffeted forests south of Boston, and the Blue Hills Observatory recorded hurricane speeds of over 150 miles per hour. At the Arboretum, staff members hunkered down in the darkness of the Administration Building, listening to the creaks and groans of the trees. The worst of the storm lasted only a few hours. The next morning, staff awoke to a grim scene. The Arboretum suffered greatly: over fifteen hundred trees had been claimed by the winds. Much of the damage befell the Arboretum's woodland areas, including Hemlock Hill, where at least four hundred native hemlocks (*Tsuga canadensis*) lay in splinters. Arboretum staff responded to this cataclysm by planting hundreds of hemlocks in their place, some as large as six feet tall.

The storm would prove to be the most destructive in the recorded history of New England, just one in a series of events that transformed the Arboretum's natural woodlands—its marks still visible today. Yet in many ways, the natural history of Hemlock Hill, and the Arboretum woodlands in general, has been a story of ongoing landscape management. Without human intervention, ecosystems respond to disturbances like hurricanes, fire, and even secondary regrowth after agricultural land is abandoned, through the process of *succession*—or the gradual change in species structure in an ecological community. Since the beginning of this successional process for the Arboretum woodlands, starting when Bussey set aside reforestation land and allowed seedling thickets to become established, this gradual change has been continually manipulated, especially in response to large-scale disturbance like the hurricane. This management, of course, raises questions about the very conception of *natural* succession and whether strategies often intended to contribute to (and perhaps simply expedite) these ecological changes are, in fact, additional forms of disturbance.

In 1930, nearly a decade before the hurricane caused ecological upheaval across New England, Arboretum botanist Ernest Jesse Palmer presented an extensive survey of the Arboretum's spontaneous flora, cataloging biodiversity throughout much of the grounds—including its woodlands. Alongside his thorough inventory of each area of the living collections and the underlying geology of the landscape, Palmer hinted ominously at the effects of aggressive exotic plants on native flora. His account is particularly notable for its description of the colonization of highly disturbed areas, such as the abandoned quarry south of Bussey Street, by an "uncommon" assemblage of herbaceous weedy species like green foxtail (*Setaria viridis*), black nightshade (*Solanum nigrum*), and common vetch (*Vicia sativa*). These species, notably absent from his inventories of the diverse and richly populated woodland areas, had only begun to take hold on the grounds. The time between Palmer's and ours marks an ecological transition for many of the Arboretum's natural areas, with the slow creep of invasive plants gradually shifting the compositions of species among these woodland fragments.

Most of the first weedy species to show up in New England arrived with European settlers beginning in the seventeenth century. Well-adapted to continually disturbed conditions, many of these species established themselves in parts of the Arboretum. A second wave of non-native introductions arrived on a network of exploration and plant trade connecting Western nurseries and botanical institutions with East Asia beginning in the 1860s, resulting in the rapid importation of thousands of potentially invasive species. Through its legacy of collection and distribution of exotic plants, the Arboretum played its part in popularizing many of these species, such as Oriental bittersweet (*Celastrus orbiculatus*) and Amur cork tree (*Phellodendron amurense*).

Today, the control of invasive plant species is outlined as an ongoing objective in the Arboretum's *Landscape Management Plan,* although many of these interventions are conducted on an *ad hoc* basis, given that most horticultural resources are invested in the more manicured portions of the living collections. Nonetheless, occasional efforts have been devoted to this end. Peters Hill Woodland, for instance, was subject to a three-year project conducted by the Hunnewell interns, starting in 2008, with the last two years focused primarily on removing woody plants like cork tree and castor aralia (*Kalopanax septemlobus*), which had escaped from the surrounding collections. Control of the botanical composition of urban woodlands—particularly those in close proximity to historically disturbed areas—is often costly, however, requiring horticultural care be diverted from the accessioned collections. Moreover, the management of invasive species using mechanical and chemical methods raises questions about the very idea of preserving ecosystem processes, further muddying our understanding of how landscapes continually disturbed by human intervention could be construed as natural.

Introduced insects and pathogens have also inspired radical management changes in the

JONATHAN DAMERY

Oriental bittersweet (*Celastrus orbiculatus*) twines atop castor aralia (*Kalopanax septemlobus*). Both are abundant escapees from the Arboretum's cultivated collection, observed here in Peters Hill Woodland.

woodlands—a point illustrated by the arrival of hemlock woolly adelgid (*Adelges tsugae*) at the Arboretum in 1998. After the initial discovery of this destructive pest on Hemlock Hill, a substantial effort on the part of the Arboretum's horticulture and curation staff culminated in the accessioning of over nineteen hundred existing trees (some nearly two hundred years old), allowing for the close monitoring of the spread of adelgid and its impact on the hemlock population. Today, the remaining mature hemlocks—many of them originally planted in response to the destruction of the Hurricane of 1938—owe their survival to annual treatment with a soil- and trunk-injected insecticide, imidacloprid. Where mature trees have fallen or been removed, dozens of recently planted Chinese hemlock (*Tsuga chinensis*)—naturally resistant to the ravages of the adelgid—reach up to fill canopy gaps. In 2006, the Arboretum also planted sapling oaks (*Quercus montana, Q. coccinea, Q. velutina*), shagbark hickories (*Carya ovata*), and sugar maples (*Acer saccharum*) on the southeast side of Hemlock Hill.

To echo Palmer's observations from 1930, "The line between Nature's great wild gardens and those planted and tended by man is not a hard and fast one … Nature herself is the builder if not the designer, guided only by man's selection and aid in planting, pruning and cultivating the things he deems most desirable." Across its rocky terrain, Hemlock Hill bears the marks of past attempts to preserve what Sargent had once deemed "the great natural feature of the Arboretum" through generations of stewardship. While a walk in its cool and shady understory may mentally transport us to the "primeval" New England forest that even

RICHARD SCHULHOF

Arboretum arborist Robert Ervin holds a branch from an adelgid-infested hemlock (notice the cotton-colored egg masses), which was felled within a research plot on Hemlock Hill in early 2005.

PHOTOS BY DANNY SCHISSLER

Canada mayflower (*Maianthemum canadense*) is an abundant spring ephemeral on Hemlock Hill, while spotted cranesbill (*Geranium maculatum*) is more commonly observed in Peters Hill Woodland.

Palmer envisioned there, the turbulent history of this forest fragment and its resulting character is perhaps the most challenging to our notion of what constitutes a natural woodland.

Ecology of the Urban Woodland

Natural or not, the Arboretum's woodlands support a great deal of biodiversity. In contrast to the cultivated collections, the successional composition, varied topography, and increased leaf litter and woody debris of these areas provide suitable habitats for a variety of native and non-native species. The woodlands harbor a variety of deciduous hardwoods, conifers, shrubs, herbaceous species, ferns, mosses, and fungi. The woodlands also provide habitats for a range of fauna that often avoid open forests and humans. Snags—dead trees that remain standing—and decaying holes in trunks provide shelter for cavity-nesting birds. Tall trees with dense canopies offer nesting opportunities for larger birds of prey. In the shady understory, reptiles and amphibians make homes among the leaf litter and decaying logs. Wild turkeys forage for acorns and nuts from beeches and hickories. A variety of mammals—coyote, deer, foxes, rabbits, raccoons, opossums, squirrels, chipmunks, voles, and field mice—utilize the Arboretum woodlands.

In addition to supporting biodiversity, these woodlands provide a range of ecosystem services that benefit outlying collections. Given the Arboretum's location in a densely populated urban environment, the entire landscape faces an exceptional set of disturbance and climatological factors. The constant pressure of competing species, exotic wildlife, and invasive pests and pathogens is compounded by elevated air and soil temperatures, carbon dioxide, ozone and nitrogen levels, decreased humidity and water availability, soil compaction, and the presence of pollutants. The preservation of urban forests combats these factors by promoting soil building and moisture retention, erosion prevention, temperature control, and carbon sequestration. As Sargent had once envisioned, the Arboretum's woodlands complement the surrounding cultivated collections aesthetically, as part of a naturalistic landscape design, and ecologically, as a buffer against the often harsh conditions of the urban environment.

While the Arboretum's woodlands never became the forest plantations for the study of

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Woodland Sketches

PHOTOS BY DANNY SCHISSLER

An abundance of fungi occur in the understory of the North Woods, where fallen trees provide habitat. From left to right: shaggy mane (*Coprinus comatus*) and yellow orange fly agaric (*Amanita muscaria* var. *formosa*).

North Woods

North Woods (2 acres) is situated along eskers that overlook the Leventritt Shrub and Vine Garden. The Arboretum acquired the westernmost part from the Adams Nervine Asylum in 1926, but the remainder has been part of the Arboretum since its founding. The eastern part of North Woods has diminished over time. This area is also home to quite a few non-native species that likely escaped from the cultivated collection, including cork tree (*Phellodendron amurense*), Korean mountain ash (*Sorbus alnifolia*), and Oriental bittersweet (*Celastrus orbiculatus*).

Geology and soils: Higher pH soils (A horizon: 4.21; B horizon: 4.47) than Hemlock Hill and Central Woods; glacially deposited eskers underlain by gravel and other sediment; groundcover mostly of deciduous leaf litter.

Mid and overstory: Dominated by sugar maple (*Acer saccharum*), with an abundance of sweet birch (*Betula lenta*); interspersed with white oak (*Quercus alba*) and shadbush (*Amelanchier arborea*).

Understory: Woody taxa include many escaped species from nearby collections such as sapphire berry (*Symplocos paniculata*), euonymus (*Euonymus* spp.), honeysuckle (*Lonicera* spp.), linden (*Tilia* spp.), and zelkova (*Zelkova* spp.); herbaceous groundcover includes sedge (*Carex* spp.) and aster (*Symphyotrichum* spp.).

Wildlife species of note: Great crested flycatcher (*Myiarchus crinitus*), eastern wood-pewee (*Contopus virens*), wood thrush (*Hylocichla mustelina*), red-eyed vireo (*Vireo olivaceus*), ovenbird (*Seiurus aurocapillus*), black-throated blue warbler (*Setophaga caerulescens*), black-throated green

White trillium (*Trillium grandiflorum*) and common milkweed (*Asclepias syriaca*) are among the many wildflowers found in the Arboretum's woodlands.

warbler (*Setophaga virens*), black-and-white warbler (*Mniotilta varia*), eastern screech owl (*Megascops asio*), and eastern red-backed salamander (*Plethodon cinereus*).

Central Woods

Central Woods (6.5 acres) was maintained as pastureland before a period of regrowth beginning in the 1790s. This woodland is favored by wildlife species that prefer dense, mixed forests. While this woodland has been relatively undisturbed, containing few non-native species in comparison to other areas, the dominance of eastern white pine (*Pinus strobus*), a pioneer species, is the result of formal clearing in some areas several decades ago.

Geology and soils: Low pH soils (A horizon: 3.6; B horizon: 4.09) underlain by outcroppings of Roxbury conglomerate in many areas; heavy cover of duff and leaf litter compared to the other Arboretum woodlands.

Mid and overstory: Primarily dominated by eastern white pine, red oak (*Quercus rubra*), and white oak, with stands of immature eastern white pine and American beech (*Fagus grandifolia*).

Understory: Dominated by lowbush blueberry (*Vaccinium angustifolium*) and huckleberry (*Gaylussacia* spp.).

Wildlife species of note: Red-breasted nuthatch (*Sitta canadensis*), yellow-bellied sapsucker (*Sphyrapicus varius*), pine siskin (*Spinus pinus*), common redpoll (*Acanthis flammea*), purple finch (*Haemorhous purpureus*), red- and white-winged crossbill (*Loxia curvirostra, L. leucoptera*), great horned owl (*Bubo virginianus*), and coyote (*Canis latrans*).

DAVID CAPPAERT, BUGWOOD.ORG

The Arboretum's woodlands provide habitat for a range of fauna, and some, like the red-backed salamander (*Plethodon cinereus*), are found almost exclusively within these areas.

Hemlock Hill

Hemlock Hill, the largest Arboretum woodland, occupies 22 acres. It has had a complex history of disturbance, including the 1938 hurricane and arrival of the hemlock woolly adelgid. This woodland is home to a number of unique birds, amphibians, ferns, and herbaceous perennials that prefer the shady understory of dense forestland. Prominent non-native plants include glossy buckthorn (*Frangula alnus*), castor aralia (*Kalopanax septemlobus*), mountain ash (*Sorbus* spp.), and hawthorn (*Crataegus* spp.).

Geology and soils: Low pH soils (A horizon: 3.75; B horizon: 4.19); steep rock outcroppings on northeast side; pit-and-mound formations formed by downed trees throughout.

Mid and overstory: Heavily dominated by eastern hemlock and some red oak, along with stands of eastern white pine and sweet birch succeeding mature trees.

Understory: Dominated by Canada mayflower (*Maianthemum canadense*), wild sarsaparilla (*Aralia nudicaulis*) and hay-scented fern (*Dennstaedtia punctilobula*), with shadbush (*Amelanchier arborea*) and mapleleaf viburnum (*Viburnum acerifolium*).

Wildlife species of note: Red-breasted nuthatch, pine warbler (*Setophaga pinus*), black-capped chickadee (*Poecile atricapillus*), tufted titmouse (*Baeolophus bicolor*), red-tailed hawk (*Buteo jamaicensis*), Cooper's hawk (*Accipiter cooperii*), Virginia opossum (*Didelphis virginiana*), eastern red-backed salamander, and northern dusky salamander (*Desmognathus fuscus*).

Peters Hill Woodland

The 2.5-acre woodland on the eastern slope of Peters Hill was the subject of the Hunnewell intern project for three years (2008–2010). In 2008, the intern class surveyed the vegetation and came up with management recommendations pertaining to invasive species removal, which the following two classes carried out. Peters Hill is the most species-rich of the woodlands and provides space for the greatest number of non-native species, most notably cork tree, crabapple (*Malus* spp.), hawthorn, and Korean mountain ash.

PHOTOS BY DANNY SCHISSLER

False Solomon's seal (*Maianthemum racemosum*) and wood anemone (*Anemone quinquefolia*) are among the spring ephemerals observed in the Arboretum's woodlands.

Geology and soils: Comparatively high pH soils (A horizon: 4.28; B horizon: 4.51) due to a lack of conifers; steep slopes forming a wet ravine that provides water throughout most of the year; heavy presence of woody debris, duff, and leaf litter.

Mid and overstory: Dominated by red oak, followed by sassafras (*Sassafras albidum*), black oak, cork tree, yellow birch (*Betula alleghaniensis*), castor aralia, and a variety of other native and non-native hardwoods.

Understory: Dense understory with at least twenty-three woody species in the sample plot; abundance of native and non-native saplings, primarily cork tree; many common herbaceous perennials.

Wildlife species of note: Great crested flycatcher, scarlet tanager (*Piranga olivacea*), rose-breasted grosbeak (*Pheucticus ludovicianus*), black-throated green warbler, eastern wood-pewee, wood thrush, chimney swift (*Chaetura pelagica*), common nighthawk (*Chordeiles minor*), and common garter snake (*Thamnophis sirtalis*).

Survey methods

Woody flora was documented in a 2017 survey, based on two randomly assigned ten-meter-radius circular plots within each of the four woodlands. In Peters Hill Woodland, only one circular plot was examined along with a recreated transect first studied by the Hunnewell interns, class of 2008.

In addition, each study area was sampled as part of the 2017 landscape-wide soil survey. Ten auger samples, separated into A and B horizons, were taken within each of the four study areas and composited, producing one A- and one B-horizon sample for each natural land. These samples were sieved, air-dried, and sent to the University of Massachusetts for analysis.

CONTINUED FROM PAGE 25

arboriculture that Sargent had imagined, the unique ecosystems of these areas have served researchers working across a range of scientific disciplines. Sheltered habitats situated among woodland microclimates—such as the shady, moist understory of Hemlock Hill—have offered opportunities to study native salamander species. Mature trees in Central Woods are used in climatological and phenological studies. Peters Hill Woodland, along with the "urban wild" of Bussey Brook Meadow, present unique successional models of minimally managed urban vegetation and the ecosystem services provided by cosmopolitan assemblages of species found in such areas. Most recently, former Living Collections Fellow Jenna Zukswert collaborated with other staff members to conduct an Arboretum-wide survey of soils and species composition within the woodlands. Data acquired through these projects can help researchers understand the response of urban woodlands and their inhabitants to a changing climate.

Resistance of Nature

Since the time of Benjamin Bussey and the wayward philosophers for whom he opened his lands, the forest fragments now situated on the Arboretum's grounds have offered a space for rejuvenation and a retreat from the hum of city life. Sargent and Olmsted—both profoundly influenced by an English tradition of naturalistic park design—incorporated these woodlands as a visual backdrop for the accessioned plant collections, adapting land that Olmsted described in a 1880 letter to author Charles Eliot Norton as largely unfit for cultivation. Today, the Arboretum's woodlands provide visitors a sense of tranquility and privacy

JAY CONNOR

The Arboretum woodlands—all visible from this springtime vantage in 2005—record a long trajectory of landscape management practices within a highly modified urban environment.

often missed among the more open and ordered character of the cultivated collections. Here, the allure of wildness and the excitement of spontaneity play out in chance encounters with the seemingly natural.

But the character of such spaces begs the question: what is truly natural in an era of accelerated ecological upheaval? What role do such spaces—shaped continuously by the interplay of environmental stochasticity and human impulse—play in the Arboretum landscape today? And finally, how might we manage these spaces to reap the spiritual and ecological benefits they provide, while acknowledging the realities of our rapidly changing urban environments? In the words of Palmer, "There is a constant effort of Nature to reassert her sway and reclaim for herself the areas that men have planted. Even in the best kept gardens this jealous resistance of Nature is not entirely overcome." At the Arnold, the genius of Sargent and Olmsted's collaborative vision lives on in these naturalistic, if not entirely natural, interstitial spaces between the cultivated and the wild—not only in their physicality, but in the way they touch our primal selves, helping us forget, if only for a moment, that we're walking in a garden.

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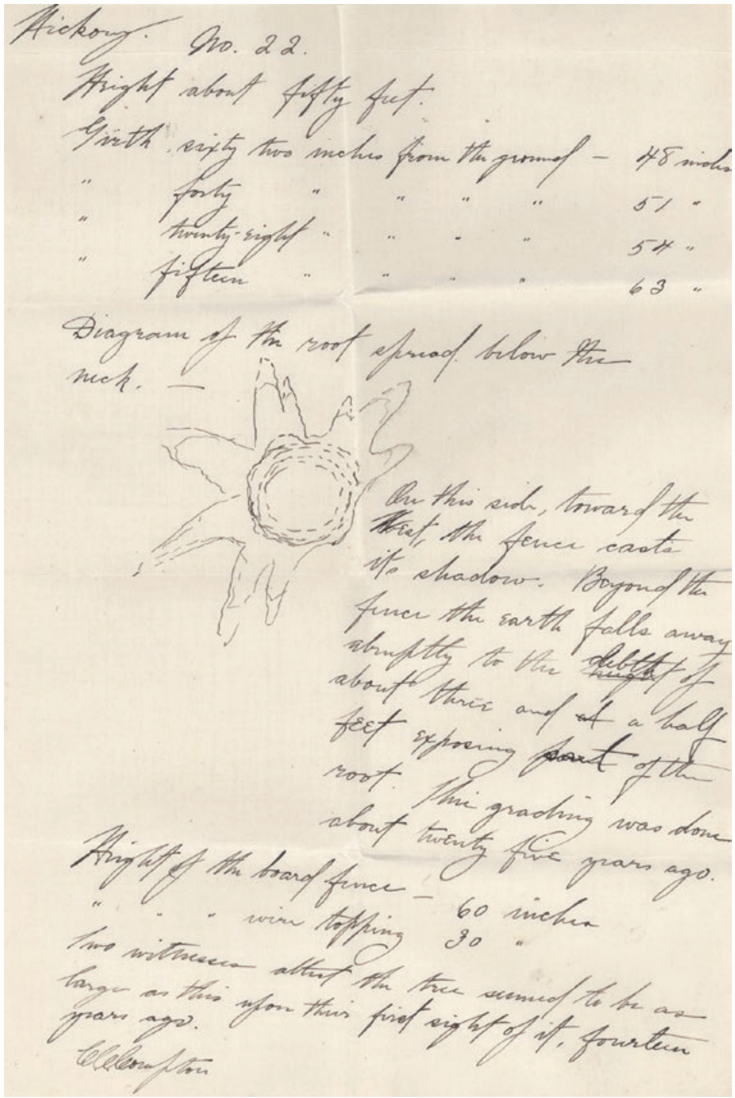
Hickory Fever: Doing Taxonomy by Mail

Jonathan Damery


Hickory. No. 22.
Hight about fifty feet.
Girth sixty two inches from the ground – 48 inches
" forty " " " " 51 "
" twenty-eight " " " " 54 "
" fifteen " " " " 63 "
Diagram of the root spread below the neck. —
On this side, toward the street, the fence casts its shadow. Beyond the fence the earth falls away abruptly to the ~~height~~ depth of about three and ~~at~~ a half feet exposing ~~part~~ of the root. This grading was done about twenty five years ago.
Hight of the board fence – 60 inches
" " " wire topping 30 "
Two witnesses attest the tree seemed to be as large as this upon their first sight of it, fourteen years ago.
C.C. Crampton

Botany in the early years of the Arnold Arboretum required a good postman. Boxes of photographs and herbarium specimens passed back and forth on the railroad. Taxonomic questions would follow in letters, along with requests for more specimens (and usually more again). Charles Sprague Sargent, the founding director of the Arboretum, famously obsessed over the taxonomy of hawthorns (*Crataegus*). His work was comprehensive and exhaustive, leaving no leaf or flower unturned, and as such, his letters are filled with requests for specimens, fruits, and field descriptions of these small, confusing trees. Yet if hawthorns were first on Sargent's mind, hickories (*Carya*), the prominent forest trees of eastern North America, were not far behind—often mentioned in the same burst of typewriter keystrokes.

Of course, Sargent travelled widely and frequently to study plants in the field—camping on mountainsides, riding in motorcars on dirt roads—but for a project like the *Silva of North America,* a fourteen-volume work on tree species native to the United States that was published between 1891 and 1902, Sargent needed assistants far and wide. The same was true for subsequent projects that aimed to disentangle specific taxonomic problems, like his synoptic treatment of North American hickories published in the *Botanical Gazette* in 1918. While Sargent worked on these projects—studying specimens and hand-written field descriptions at his desk on the third floor of the Arboretum's administration building—it must have felt like reconstructing a crime scene from several states away, years after the fact, with only a team of freelance detectives who could occasionally be marshalled (when time and finances permitted) to search for evidence and knock on doors to interview witnesses.

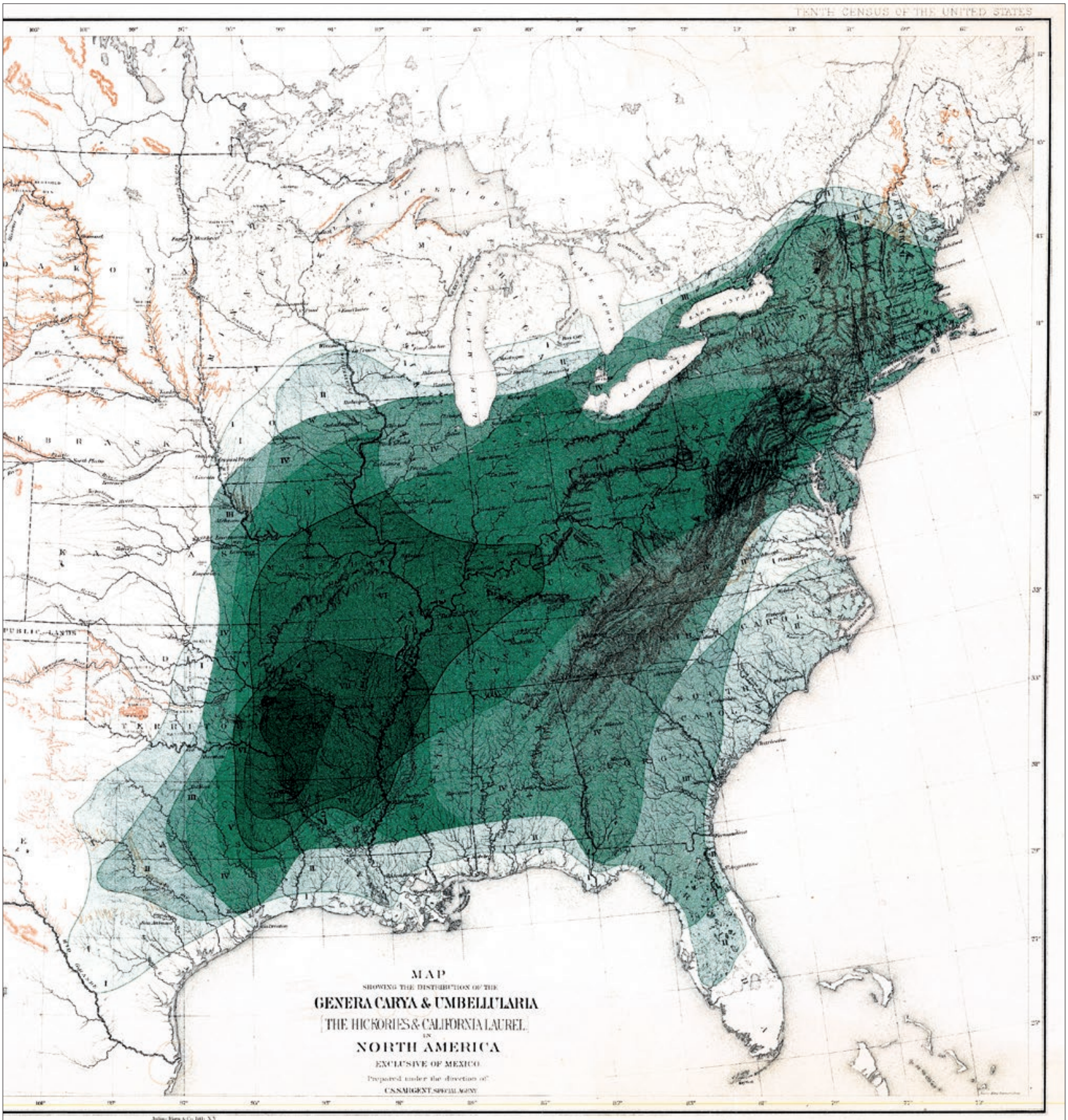
In a long and detailed letter to Thomas Grant Harbison, one of his most reliable field collectors in the southeast, Sargent professed immense confusion when it came to the hickories. "It begins to look as if all the characters on which we have been trying to base species are giving out," he lamented in 1914, after providing several pages of notes on specimens Harbison had collected. "I think that … the same species may bear globose and oblong nuts, that the leaves may or may not be pubescent, and that the bark may vary enormously according to situation."[1]

Above and facing page: Charles Sargent studied hickory (*Carya*) taxonomy with support of a large network of field correspondents, including the journalist Charlie C. Compton ("Miss Compton") in Natchez, Mississippi. "No. 22 is still puzzling," Sargent wrote in 1913, responding to this set of Compton's photographs and field notes. "Thanks to your energy and intelligent zeal we shall get to the bottom of this business sooner or later." Sargent later determined this tree, No. 22, was a black hickory (*Carya texana*).

Evidence for solving these taxonomic mysteries could be frustratingly scant. Even if someone collected herbarium specimens in the middle of the growing season, Sargent would send them back to collect again in the fall. Specimens in hand often only confirmed that others were needed. When he received fruits from a hickory that Ernest Jesse Palmer had collected in Noel, Missouri, in 1915, Sargent told him it was "one of the most remarkable of all your Hickories," yet the fruit had only wetted his desire to know more. "Will you tell me something about this tree, its size, place of growth, character of the bark, or anything else you may know about it? I have never seen any fruit like this."[2] Four years later, Palmer would send grafted material from the same tree—now considered a mockernut hickory (*Carya tomentosa,* accession 8014*A)—which still grows in the Arboretum's hickory collection. Although spindly (much smaller than expected of a centenarian overstory species), the tree offers a robust reminder of the correspondence needed to conduct this kind of taxonomic inquiry.

Special Agents

Sargent's crew of field correspondents began solidifying long before his interest in hickories. His first concerted research project was the *Report on the Forests of North America (Exclusive of Mexico),* an ambitious opening salvo launched as part of the 1880 United States Census, which aimed to describe and map the composition of forests across the country. Sargent



Sargent's *Report on the Forests of North America (Exclusive of Mexico),* published in 1884, included the first distribution maps for major North American tree genera, which were prepared by Andrew Robeson. Rather than presenting the distribution of individual *Carya* species on this map, the green shading suggests species richness—or the number of *Carya* species believed present at any particular site. The greatest density (eight species) was recorded in western Arkansas, the future location for significant collections by Sargent and his correspondents.

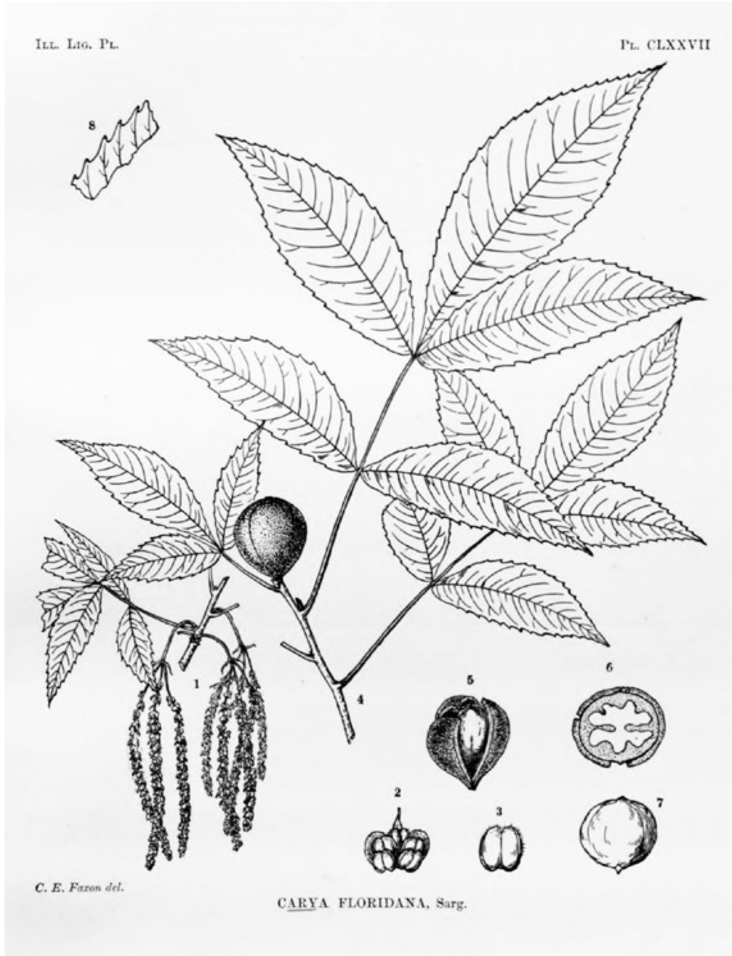
logged significant miles to research the project himself—notably botanizing forests in Utah, California, and Oregon—but to complete such a wide-ranging project, he needed colleagues that ranged just as far. Several botanists were officially enlisted as "special agents" for the four-year project, but others became informal collaborators.[3]

A number of the oldest hickories still growing at the Arboretum arrived due to the census project, including an exceptional specimen of pecan (*Carya illinoinensis,* accession 12913*A), tucked in the back corner of the hickory collection, where its straight trunk lofts the canopy nearly one hundred feet high. Fruit for this accession arrived from the ornithologist Robert Ridgway, the first full-time curator of birds at the United States National Museum, who had collected the material near Mount Carmel, Illinois, in 1882. Although Ridgway was based in Washington, DC, he continued to study the landscape of Illinois—his home state—while he prepared a two-volume treatise on the birds of the state.

Ridgway was an unofficial census correspondent. Yet his research on woodlands in southern Illinois (and adjacent portions of Indiana) was so rigorous—far surpassing the needs of the census—that Sargent encouraged him to publish his findings independently. The article ran forty pages in the *Proceedings of the United States National Museum,* published in 1882, the same year the Arboretum received seed shipments from Ridgway. In the report, Ridgway described the pecan as "one of the very largest trees of the forest" with a canopy that often "reared conspicuously above the surrounding tree-tops, even in a very lofty forest," and he noted that one tree (unfortunately measured after it had been felled) had been documented with a canopy 175 feet (53 meters) high and a trunk diameter of 5 feet (1.5 meters).[4] The pecan in the Arboretum collection, while not yet that size, suggests this pedigree.

A stand of nine shellbark hickories (*Carya laciniosa,* accessions 12898 and 20094) that grow in park-like planting atop Valley Road also arrived in 1882 from another census correspondent. George Washington Letterman had been enlisted as an official special agent to study the forests west of the lower Mississippi River, although the hickories were collected near his home in Allenton, Missouri, about thirty miles west of Saint Louis. Letterman was a school teacher and scheduled fieldwork around his classroom duties. In a humorous note to George Engelmann, a prominent botanist who was a physician and a close mentor to Sargent, Letterman alluded to this time constraint in April

An unattributed *Garden and Forest* editorial from 1889 suggested that hickories "are the despair of people who expect to be able to fit exactly every plant they encounter with the printed description of it in some book." This supplementary illustration of a shellbark hickory (*Carya laciniosa*) was based on a Robert Ridgway photograph from southern Indiana.



Above and facing page: "This particular form of Hickory is quite new to me and I am anxious to have further information about the tree," Sargent wrote to Bryant K. McCarty—a pineapple farmer in Saint Lucie County, Florida. The herbarium specimen had been forwarded in 1911 from Robert Morris, Sargent's collaborator on hickory matters. Sargent later named the species *Carya floridana*—the scrub hickory—and Charles Faxon provided the first illustration.

1881. Because so many students had the measles that spring, he suggested he might cancel classes and gain an unexpected week for census fieldwork.

In the same note, Letterman also described the perplexities of hickories. "It seems that the hickory nuts puzzle every body, especially those who have not been able to see the trees in all stages of growth year after year," he wrote, referring to an inquiry from the Illinois botanist George Vasey. "Don't you think that something better than what the books now contain on the subject should be given to botanists? In case you undertake to revise the genus, I should be glad to procure all the material obtainable here for you."[5]

Engelmann responded with a brief postcard: "Too early to work up *Carya,* but we must go on gathering material."[6] The epistolary trail with Engelmann ends there, although Sargent, writing two decades later, recalled that Letterman made substantial collections for Engelmann near Allenton and that those collections included "many notes on the Oaks and Hickories."[7]

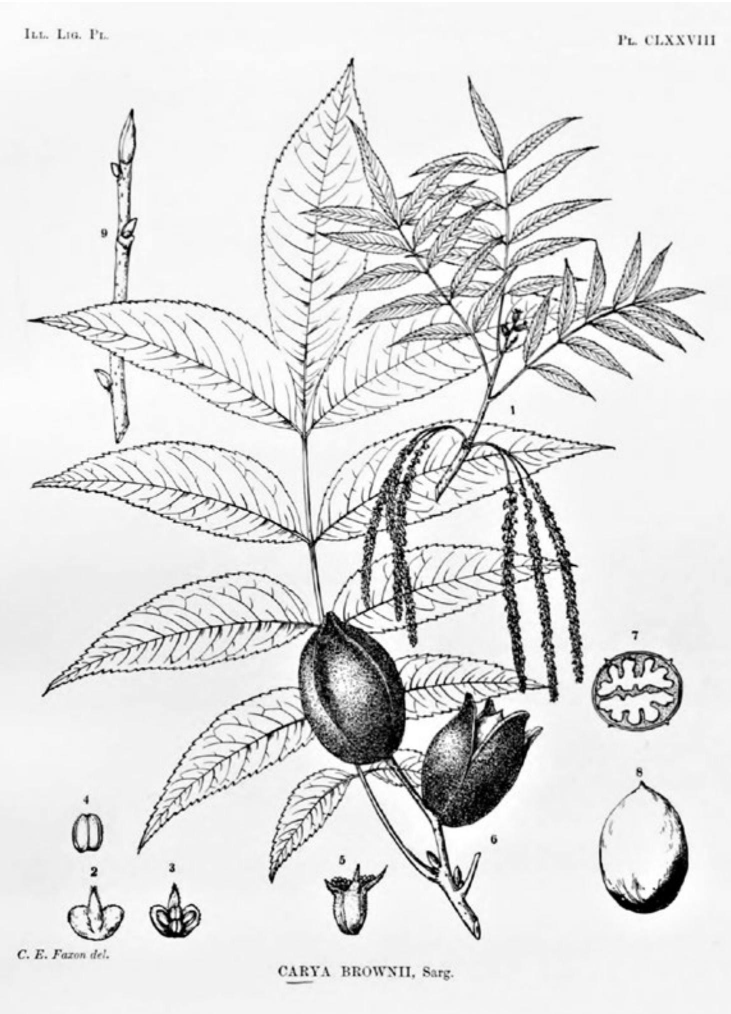
Entirely Overlooked

For his part, Sargent didn't seem especially interested in the hickories during the census years, and he wouldn't begin to wade into the subject until an 1889 *Garden and Forest* article, where he attempted to parse out whether the genus should be called *Carya, Hicoria,* or *Hicorius,* opting for the final option.[8] An unattributed editorial ran after this nomenclatural treatment, celebrating the hickory as "purely an American tree," given that none of the Asian species were known to Western botanists at the time. As the "conductor" for the magazine (essentially the publisher), Sargent must have conceded the general points, including, quite notably, an admission of taxonomic confusion. "More Americans know the Hickory-tree when they see it than any other of our trees," the author wrote. "That is, they know generally, the Hickory, without distinguishing the different species, which is hardly surprising, since botanists themselves are often perplexed over questions concerning the proper limitations of these species."[9]

Even so, when Sargent covered the genus in the seventh volume of *Silva of North America,* published in 1895, he sounded little taxonomic alarm, although he footnoted a new variety of pignut hickory (what he called *Hicoria glabra* var. *villosa*), based on a tree Letterman had documented in Allenton, and he offered passing descriptions of several unnamed hybrids. Yet, hickories weren't alone in escaping Sargent's

ARNOLD ARBORETUM HERBARIUM

ARNOLD ARBORETUM HERBARIUM



Above and facing page: After Sargent visited Van Buren, Arkansas, in March 1909, his local collaborator, George Brown, collected flowering herbarium specimens that Sargent would use to describe a new hybrid: *Carya × brownii.* Charles Faxon provided the first illustration of this hybrid.

taxonomic scrutiny; his research interests had just begun shifting from nomenclatural synthesis to novel taxonomy. Over the preceding years, Sargent had described as few as twenty-one new taxa for an assortment that included firs (*Abies*) and false box (*Gyminda*)—not counting nomenclatural transfers like *Carya* to *Hicorius.* In 1895, however, Sargent proposed another fourteen names—many of them oaks (*Quercus*)—suggesting he was becoming more confident of his own taxonomic eye. Those numbers continued to grow, and by 1907, he had added over three hundred names in *Crataegus* alone.

According to Sargent's correspondence records (which become more consistent in the Arboretum archive in 1902 when he began saving carbon copies of his typewritten letters) his interest in hickories began gaining traction in 1908. That fall, around the time that hickory fruits would be ripening, he received a letter from a physician-turned-botanist named Robert T. Morris, who inquired about *Carya buckleyi* (now considered *C. texana,* the black hickory). Although the two men had corresponded about hickories the year before, Morris's question about the black hickory seemed to awaken Sargent's curiosity. "I confess that I, as well as all other botanists in recent years, have entirely overlooked this tree," Sargent wrote back, referencing the taxon at large, rather than an individual plant. "The name does not appear in my *Silva* for some unaccountable reason as I was familiar with the paper [in the *Proceedings of the Academy of Natural Sciences of Philadelphia*] where it was first described … I shall be very glad of some of the nuts if you can spare them for me."[10]

Morris had obtained a letter about the species from a grape breeder in northeastern Texas named Thomas Volney Munson. Sargent wrote to Munson immediately, even before responding to Morris, and offered to trade a selection of Chinese grape seedlings (grown from Ernest Henry Wilson collections) for fruit and herbarium specimens from the hickory.[11] This exchange proved successful. Within three weeks, Munson had already shipped the specimens, along with a list of grape species he was interested in obtaining. Sargent, however, was rarely satiated, and he requested that Munson return to collect half-a-dozen specimens of branches with winter buds.[12]

The following March, Sargent rode the rails to Texas to see the inexplicable hickory himself. He also stopped in central Arkansas, where he botanized in the alluvial bottomlands near the town of Van Buren with the engineer of the municipal waterworks, George M. Brown, who was an avocational student of the flora. Munson and Brown were new collaborators for Sargent, and he took fondly to both. When he returned to Brookline, hickory propagules had already arrived from Brown. Sargent requested flowering specimens from both men—apparently his trip had missed the spring flush—and although he reminded them to gather fruiting specimens in the fall, Sargent ultimately returned to observe the plants himself.[13,14] He visited both men in early October and also rendezvoused to talk about hickories with his longtime collector Benjamin Franklin Bush, who ran a general store near Kansas City, Missouri, and who had already proven himself a keen botanical observer for Sargent's hawthorn research.

While he was travelling that fall, Sargent collected seed for at least nine Arboretum hickory accessions. Only one plant from this collecting trip is still growing at the Arboretum today, representing our oldest accession of the nutmeg hickory (*Carya myristiciformis,* accession 6048*C), a rare species, which Sargent collected in Arkansas. It is now an impressively straight-trunked specimen in the center of the hickory collection, growing not far from a smaller-statured black hickory (*C. texana,* accession 12892*C), sent from Brown in 1912, and a pignut hickory (*C. glabra* var. *megacarpa,* accession 18062*A), which Bush collected in southern Illinois that same year. Sargent's enthusiasm was officially brimming.

Hickory Problems

If the unusual black hickory in Arkansas initially sparked Sargent's concerted investigation of the genus, publication projects breathed oxygen onto the flame. While Sargent began working on his first edition of the *Manual of the Trees of North America,* distilling his work on the fourteen-volume *Silva* into one comprehensive guidebook (published in 1905), he began simultaneously proposing and describing new taxa in serialized publications titled *Trees and Shrubs: Illustrations of New or Little Known Ligneous Plants.* These were released incrementally, and his research on hickories would appear in the final installment, published in 1913. As the publication date approached, he began firing off letters to collectors, urging them for information about hickories.

Many of the correspondents were recent hawthorn collaborators—tried and tested in their ability to field ceaseless requests—although Sargent even turned to his old census agents, perhaps because their trees were already growing in the Arboretum collection. "You used to be very keen about Hickories and I hope that you will have a relapse of the Hickory fever and make large collections again," he wrote to Letterman in 1911, even though the two hadn't corresponded significantly over the intervening years. "The genus has got to be reworked and I am getting together as much material as possible for this purpose that it may make a better showing in the new edition of my *Manual* than it does in the first edition."[15] He also wrote to Ridgway the same year, and Ridgway responded with characteristically meticulous and detailed handwritten notes, and professed enthusiasm for the project. "I have long been convinced that the genus is in sad need of overhauling," he wrote, "and feel sure there are several more good species than are recognized in the books."[16]

When Sargent ultimately published his treatment on the genus in 1913, he proposed seven new species or hybrids along with an additional thirteen varieties—marking his first published effort to disentangle and redefine taxonomic parameters within the hickories. (One of these hybrids, *Carya × brownii,* was based on an individual tree in the bottomlands of the Arkansas River, where it had puzzled Sargent and Brown back in 1909.) Yet this research on the hickories still proved unsatisfactory. Harbison—Sargent's faithful southeastern collector—had made extensive collections of hickories the same fall the report was published. "I must say the more I see of them the more confused I become," Sargent wrote about material Harbison had sent from Georgia and Alabama, typing his frustrated missive on New Year's Eve. "It is evident, I think, that we cannot depend much on the fruit as I once supposed we could and that we must try for other characters, bark, habit, location, habitat, winter-buds, pubescence, etc. I do not suppose that there are a great many species but the trouble is to limit what there are. It seems to me that it will be impossible to properly know them without a great deal more field observation."[17]

Notes like this became a recurring refrain over the next several years, as he repeatedly asked Harbison, Palmer, and others for additional information about specimens that had arrived. Sargent would ultimately publish his final taxonomic treatment of the genus in 1918, when it appeared in the *Botanical Gazette.* He proposed more than twenty additional taxa, many of them varieties and forms. By the number of proposed names, this placed hickories in the top three genera that Sargent had studied, behind only oaks and, of course, hawthorns.

Sargent based his description of *Carya* × *dunbarii* on herbarium specimens from this tree, which John Dunbar had observed near Golah, New York. Richard Horsey, who worked with Dunbar at the Rochester Parks Department, photographed the tree and an unnamed man (could it be Dunbar himself?) in December 1918, shortly after publication of Sargent's final report.

Sargent closed that final report by describing thirteen individual trees that had been observed by John Dunbar, the assistant superintendent of the Parks Department in Rochester, New York. Sargent provided precise notes about the color of the branches and the shape of the fruit. None of these thirteen plants resulted in accessions that are still growing in the Arboretum collection, although we still have eight plants (representing seven unique wild provenances) from Dunbar and his collaborator Bernard H. Slavin. Sargent praised the collectors and noted that no region had been more "carefully examined" for hickories than western New York. To Sargent, the discovery of confounding individuals there simply proved that other regions needed to be studied with the same rigor. If so, he suspected additional taxa would be discovered.

Nevertheless, hickories faded from Sargent's correspondence, and he would never publish another taxonomic treatment of the genus. Whether this report absolved what Sargent described as the "hickory problem," however, remains unclear. Several months before the report was published, he wrote a letter to Reginald Somers Cocks, a professor at Tulane University, who had been a frequent correspondent on the genus. "I have about finished up what I can do with *Carya,*" he wrote, "not a very satisfactory work."[18]

More than American

Notably, during much of this period, hickories were one of the few tree genera that appeared unique to the eastern North American flora. In the unattributed *Garden and Forest* article from 1889, the author—again, presumably articulating ideas approved by Sargent—had described the wood and fruits in superlative terms. "As a nation we owe much to the Hickory tree, and we have good and just reason to be proud of it," the author wrote, even suggesting that the lightweight yet durable carriages crafted from hickory had allowed equestrian breeders to develop the American trotting horse, "that race of horses which every American looks upon in his heart of hears with joy and admiration."

Then, in 1915, Sargent received herbarium specimens of a Chinese hickory from the collector Frank Nicholas Meyer, who had first observed the fruits being sold at a market in Hangzhou, in eastern China. Sargent acknowledged receiving the specimens in a letter to Meyer the following January, and, of course, he requested more information about the size and abundance of the trees, not to mention photographs.[19] Sargent's intrigue about the discovery, however, is perhaps most evident in his account of the species in *Plantae Wilsonianae.* Sargent edited the three volumes, published between 1913 and 1917, yet of nearly eight hundred names proposed for new Chinese plant taxa (not counting nomenclatural transfers), most came from other Arboretum staff—prominently Alfred Rehder and Ernest Henry Wilson—as well as European colleagues like Camillo Schneider and Bernhard Koehne. Sargent authored only seven new names: six hawthorns and one hickory—what he called *Carya cathayensis.*

"Since the finding in China of a species of *Liriodendron* [tulip tree] and of *Sassafras,* previously believed to be monotypic genera of eastern North America, no addition to our knowledge of the distribution of the trees of the northern hemisphere is so important and interesting as Mr. Meyer's discovery of a representative of the genus *Carya* in Asia," Sargent declared in the publication, noting that progressively few genera appeared unique to eastern North America. "In China," he continued, using a tone that could suggest a trace of disappointment, "there are many endemic trees."[20] Strangely, Sargent never acquired seed of this species from Meyer—perhaps suspecting they would be unable to grow at the Arboretum, given that it was discovered in the humid subtropics—and the only material ever collected (by Peter Del Tredici in 1989) never made it out of the greenhouse. It is currently on the list of desiderata for the Campaign for Living Collections.

In 1915, Sargent learned that the American hickories like the charismatic shagbark (*Carya ovata*), photographed in Rochester, New York, above, had Asian relatives. That summer, Frank Meyer photographed a large Chinese hickory (*Carya cathayensis*) on the edge of a bamboo grove in Zhejiang Province. "The wood is said to be tough and strong and appreciated as handles for agricultural tools," Meyer noted.

Confidence in the Commonplace

Botanists would eventually begin consolidating many of the hickories Sargent had named. Because so many of the taxa were varieties, many of the names have been dropped in recognition of more morphologically diverse conceptions of each species. "Phenotypic variation from tree to tree is often considerable and difficult to quantify," Donald Stone wrote in his treatment of the American species in the *Flora of North America,* published in 1997. "Most of this variation undoubtedly results from adaptation to local and regional conditions; hybridization has probably played a subtle role as well."[21] Stone included eleven species—down from the fifteen in Sargent's final report—and referenced another seven species globally (most in eastern Asia, one in Mexico), although these numbers have fostered ongoing debate.[22]

In the spring of 1918, as Sargent was wrapping up work on his final hickory report, he wrote to Harbison, suggesting that certain hickory species had been neglected by botanists, given their general abundance and familiarity.[23] It was this fundamental spirit that inspired what must be, even still, one of the most widespread and detailed morphological studies of the North American members of the genus—an impossible endeavor without the nuanced observations by Sargent's cadre of mail correspondents. This collaborative effort also provided the centenarian core for the Arboretum's robust collection of hickories, which was one of our first to be accredited by the American Public Gardens Association's Plant Collections Network in 2002 (back when the network was known as the North American Plant Collections Consortium). Current field-collecting efforts continue to prioritize the genus, maintaining the intellectual passion of Sargent and his collaborators long ago: the confidence that even among the "plants which have been considered too common to collect," something new can always be discovered.

Endnotes

1 Sargent, C. S. 1914. Sargent to T. G. Harbison, 2 March 1914 (volume 8, page 8). Charles Sprague Sargent (1841–1927) papers, Arnold Arboretum Horticultural Library, Harvard University. (All Sargent correspondence below from the same archive, unless otherwise noted.)

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3 For the term "special agent" applied for collectors other than Sargent himself, see Sargent, C. S. 1902. *Silva of North America,* 13 (pp. 79–80.)

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Existing through Change: *Quercus alba*

Michael S. Dosmann

On a magnificent bird's-eye-view map of the Arnold Arboretum, prepared in 1927, paths and hillsides, collections and trees are depicted in such clear detail that you can easily imagine gazing down from a floating hot-air balloon (see pages 18–19). The map hangs in the Arboretum library, and perhaps the most striking specimen is a tree drawn on the northeast slope of Peters Hill, a lone shepherd guarding an endless flock of Charles Sargent's beloved hawthorns (*Crataegus*).

This venerable singleton is a double-leadered white oak (*Quercus alba*), now towering above the Arboretum's crabapple (*Malus*) collection, which replaced most of the hawthorns after World War II. The tree reaches an impressive spread of 28 meters (92 feet) and height of 17.2 meters (56 feet)—the southwestern bole is slightly taller—but most notable is its girth, no doubt exaggerated by the twin stems, which are swollen with crown gall (*Agrobacterium tumefaciens*). A slight seam meanders through this burly base, suggesting the stems are fused at ground level, where the diameter is 2 meters (6.5 feet). Impressive is an understatement.

Despite its size (and obvious age), a glance at the tag reveals the tree's accession number: 346-2010*A, meaning it was accessioned just eight years ago. Ordinarily, the Arboretum receives accessions as wild-collected seed, nursery purchases, cuttings from sister gardens, or other means (there are thirty-three different options), yet this tree is an "existing plant." It was officially given its unique accession number *after* it had been found growing in place.

Of the 14,722 accessioned plants in the permanent collections, almost 20 percent are existing plants. Over half of these were accessioned since 2007, through an initiative led by Manager of Plant Records Kyle Port, which officially brings important specimens from managed areas into our systems to be measured, tracked, and studied. Even without an accession number, these trees with opaque provenance received arboricultural care; curatorial record-keeping adds collections value.

Our oak first shows up in Arboretum archives on a detailed 1894 topographical survey of Peters Hill made for the City of Boston, a year before this area became part of the Arboretum. At first glance, the tree appears to be marked with an *8*, but this figure actually represents the two stems. To establish a firmer age, I recently extracted an increment core and counted the rings from the southwest stem, 138 centimeters (54 inches) above the ground. The wood was hard and intact most of the way until I approached the center and hit a soft pocket. Even so, with 70 percent of the core intact, I counted 142 rings. Assuming the unrecovered portion represented an additional 60 rings, that leader reached its position in the 1810s; germination would have been several years earlier. With this information, we've affirmed the tree to be of local, wild provenance.

In 1937, Hugh Raup shared his thoughts about several existing white oaks on Bussey Hill. One tree's rings, counted after a fatal lightning strike in 1931, dated to 1666. Raup pondered what this tree had witnessed, particularly landscape changes from forest to agriculture to woodland again. Among all the changes, however, Raup stated "the later scenes [of the Arboretum] are the strangest." The bizarre combination of exotic and local plants surpassed the previous centuries' revolution: the "great white wings" of the dove tree (*Davidia involucrata*) and "impossible maples with copper-colored bark that peels off in thin sheets" (*Acer griseum*).

Change is inevitable, and the Arboretum's naturalistic landscape is no exception. In another century, perhaps a new collection will replace the Peters Hill crabapples just as they eclipsed the hawthorns. With good graces, I hope our white oak is around to bear witness to the transformation, for as Raup wrote of the Arboretum, "the only continuity is in the inherent charm of the place and in the lives of the ancient oaks."

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